POLYTECHNIC UNIVERSITY OF CATALONIA
Superior School of Industrial, Aerospace and Audio-visual Engineering of Terrassa (ESEIAAT)

Degree:

Master's Degree in Technology and Engineering Management

Student:

Salma Zouid El Bakkali

Title:

Study of the requirements and project management plan of a system to provide relevant environment information for outdoors sports practitioners in urban areas

Final Master Thesis Director:

Maria Gonçalves Ageitos

Date:

27th April 2020

Call:

Extension Fall Semester 2019/2020

Document Content:

Report

To my beloved parents, Mrs. Meriem El Bakkali and Mr. Mohamed Zouid, who taught me that the best kind of knowledge to have is which is learned for its own benefit and encourage me to work hard for the things that I aspire to achieve.

“La inspiración existe, pero tiene que encontrarte trabajando.”

“Inspiration exists, but it has to find you working.”

Pablo Picasso

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Escola Superior d'Enginyeries Industrial, Aeroespacial i Audiovisual de Terrassa

ACKNOWLEDGEMENTS

First of all, I would like to express my deepest gratitude to my supervisor Prof. María Gonçalves for her constant follow-up and her ability to guide and facilitate methods for the successful and proper development of the project. She has been a continuous support before and during the development of the project and she encouraged and steered me in the right direction every time the road got tough.

I would also like to thank my family, specially my parents and my cousin Omaima who have helped me, motivated me and have been involved in one way or another in this project. They have been interested in every detail of the project and in some other occasion they have helped and guided me in the process by their sincerest opinion.

Last but not least, I am sincerely grateful to all these people from familiars, friends, colleagues or even unknown people who helped me to develop my thesis by answering the survey or even let me interview them to develop the empathy and testing process.

ABSTRACT

The impact of air quality in human's health have attracted much attention in the past decade furthermore if we consider sports practitioners.

In the first part of this thesis, it has been analysed how air quality can affect human's health in particular how it could affect outdoors sports practitioners main practicing their sports.

After this analysis a solution has been presented to some users, a mobile app that can let them check the air quality in any area they want and let them know which is the best time to go out for practicing their sports.

An agile process has been followed to define the main app functions and features, and from here it was being devised a project management plan for its development including an economic and environmental-social analyses of the future development of the app if its introduced in the market.

Keywords: air quality, air pollution impact, human's health, sport practitioners, project management plan, air quality app, development of an app**.**

El impacto de la calidad del aire en la salud humana ha atraído mucha atención en la última década, además, si consideramos a los practicantes de deportes.

En la primera parte de esta tesis, se analizó cómo la calidad del aire puede afectar la salud humana, en particular cómo podría afectar a los practicantes de deportes al aire libre mientras practican.

Después de este análisis, se ha presentado una solución a algunos usuarios, una aplicación móvil que puede permitirles verificar la calidad del aire en cualquier área que deseen y hacerles saber cuál es el mejor momento para salir a practicar sus deportes.

El design thinking es el proceso que se ha seguido para definir las funciones y características principales de la aplicación y de esta manera se elaboró un plan de gestión de proyecto incluyendo un análisis económico y ambiental-social del desarrollo futuro de la aplicación si se introduce en el mercado.

Palabras clave: calidad del aire, impacto de la contaminación del aire, salud humana, deportistas, plan de gestión de proyectos, app de calidad del aire, desarrollo de una app.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

AQI	Air Quality Index
CO_2	Carbon Dioxide
CSIC	Higher Council for Scientific Research
EEA	European Environment Agency
EU	European Union
FMT	Final Master Thesis
IRR	Internal Rate of Return
LCA	Life Cycle Assessment
NH_3	Nitrogen Trihydride (Ammonia)
NO_x	Nitrogen Oxides
NPV	Net Present Value
O_3	Trioxygen (Ozone)
PMP	Project Management Plan
PM_X	Particulate Matter
SO_2	Sulfur Dioxide
TFM	Final master thesis
VOCs	Volatile organic compounds
VPC	Value Proposition Canvas
WBS	Work Breakdown Structure
WHO	World Health Organization

1. INTRODUCTION

Sports and environment are two aspects that, on numerous occasions, go hand in hand, and it is common to see hundreds of people exercising in both urban and natural outdoor spaces. In fact, practicing sports or, failing that, increasing physical activity, is one of the main medical recommendations aimed at improving people's health.

But, what happens when this physical activity takes place in an environment with poor air quality? What effect does pollution have on sports performance and the health of people who practise sport? Those questions have been answered in the next pages.

Nowadays, air pollution is a global problem and it is proven to kill more people worldwide than AIDS, malaria, breast cancer or even tuberculosis. However, even if air pollution is related with urban areas and large cities contamination, sometimes is a result from natural disasters. In the last decades, population living in urban areas has increased extremely since 80% [1] of the global population lives in urban areas. For that reason, the health consequences of air pollution are expected to create an increasingly larger illness burden in years to come as the World Health Organization (WHO) has noticed.

For that reason, in this project it was proposed a project plan management that consists in developing the process of the development of an information system that can solve the problem that outdoor sport practitioners face while being practicing and breathing polluted air.

So, it has been studied the air pollution in the city of Barcelona as the development of the project it is done in this city and a solution was proposed. A mobile app that can provide to their users updated data related to air quality, other environmental factors and be able to check their exposure to contaminants during all day.

The scope and timing to develop this project were defined from an early stage before knowing so much about how complex could be to detect the users need and be able to develop them as a functional idea that can be implemented in the solution.

To be able to create this information system, first it has been done an analysis of similar applications and try to fill the gap and create something unique and different as it is the feature of being able to check the daily exposure to pollution. Next, to be able to work on the features of the app, some interviews with outdoor sport practitioners were run to be able to understand the users need. From here, a design thinking process it has been followed from all the phases until arrive to an approved prototype of the solution.

Afterwards, it has been done a viability analysis to study the strategies to follow to be able to launch the app in the market. Also, an economic and environmental-social analysis was done where demonstrates the future success of the app if it's implemented.

Finally, it has been done a schedule plan for the following future steps to develop the idea and be able to launched in the market in both Apple Store and Google Play, after 10 months of development.

2. AIM

The aim of this project is to develop the information system of a digital platform as it is a mobile app, where outdoor sports practitioners in Barcelona can find the best urban place around to practice their sport considering some factors that can affect them to develop properly their activity, being the main factors to consider the health and air quality.

3. SCOPE

The project scope for the design and development process of the information system will include:

- Identification of the sports and final users who are affected by air quality and other environmental factors while practicing their sports outdoors.

- Definition of the requirements as the functions and features of the information system to the final users to identify the main problems they face while practicing their sports outdoors.

- Preliminary design of the system based on those previous requirements studied to approach different solutions and alternatives, and justification of the proposed solution considering the developed scope, cost, time, risks and quality management plans.

- Development of a prototyped solution to a level of detail matching with the requirements of the users' needs.

- Analysis of the economic, environmental and safety aspects of the proposed solution.

The deliverables developed for this project will be the following:

- Diagnostic of the current levels of air pollutants in Barcelona and relevance for outdoor sports practitioners.
    - Analysis of pollutants related to air quality and their effect on human's health considering available literature.
    - Analysis of available literature about air quality effects on outdoor sports practitioners.
    - Analysis of the air pollution in Barcelona considering available literature.

- Diagnostic of the current air quality applications and applications related to environmental factors for outdoor sport practitioners.
    - Analysis of air quality applications for runners or outdoor sport practitioners.

- Development of an information system that provides information about air quality and other environmental factors to outdoor sport practitioners.
    - Analysis of the users' needs and identification of the problem.
    - Analysis of different solutions and alternatives, and justification of the proposed solution.
    - Analysis of the requirements, features and functions for the development of the app.
    - Analysis of the economic, environmental and safety development of the proposed solution
    - Analysis of the temporal aspects which will determine the time needed to be implemented the app in the market.

All those previous analyses in project management can be defined as deliverables. The aspects studied to complete those analyses are presented below in the following chapter using the methodology of work-breakdown structure (WBS) which is a deliverable-oriented breakdown of the project into smaller components.

3.1 WORK BREAKDOWN STRUCTURE

The Work Breakdown Structure (WBS) for the development of the solution is presented in Table 1 where are decomposed the major project deliverables that organizes the work into manageable work-packages.

Level 1	Level 2	Level 3	Level 4
INFORMATION SYSTEM	**1.1.** Diagnostic of the current levels of air pollutants in Barcelona and relevance for outdoor sports practitioners.	**1.1.1.** Analysis of pollutants related to air quality and their effect on human's health.	
		1.1.2. Analysis of air quality effects on outdoor sports practitioners.	
		1.1.3. Analysis of the air pollution in Barcelona.	
	1.2. Diagnostic of the current air quality applications.	**1.2.1.** Analysis of general air quality applications.	
		1.2.2. Analysis of air quality applications for runners or outdoor sport practitioners.	
	1.3. Definition of the information system requirements.	**1.3.1.** Analysis of the users' needs and identification of the problem.	**1.3.1.1.** Surveys to users – Study Users' Needs
			1.3.1.2. Empathy Map – Learnings from interviews
		1.3.2. Definition of functions and features.	
	1.4. Preliminary design of the information system.	**1.4.1.** Proposal of different solutions and alternatives.	**1.4.1.1.** Clustering: find themes and patterns
		1.4.2. Justification of proposed solution.	**1.4.2.1.** Value Proposition Canvas: Value Map
	1.5. Final Analysis for future development	**1.5.1.** Analysis of the economic, environmental and safety development of the proposed solution.	**1.5.1.1.** Summary of the budget and study of economic viability.
			1.5.1.2. Analysis and assess-ment of the environmental implications.
		1.5.2. Analysis of the temporal aspects which will determine the time needed to be implemented the app in the market.	**1.5.2.1.** Planning and progra-mming of the proposed future work.

Table 1: Work Breakdown Structure

In the previous table related to the breakdown structure it has been split the work or deliverables to present for this project plan management in five different sections. In the second level, these five sections are presented, each section has it owns subsections

that are presented in the table as well, considering the deliverables which are presented in the fourth level.

3.2 TASK IDENTIFICATION AND DEFINITION

In project management, a task is an activity that needs to be accomplished within a defined period of time or by a deadline to work towards work-related goals complying with certain requirements related to the schedule milestones, associated schedule activities, resources required, quality, technical references between many others aspects.

So, in the next diagram it can be seen some different tasks or activities identified from the previous sections which are the most complex or interesting to develop that will add value to the thesis to be able to develop the mobile application. The tasks identified are the ones to develop the solution, however for the development of the thesis there are other activities and tasks that are not included in the figure 1, however in the Gantt Diagram it has been considered also the tasks to develop the FMT.

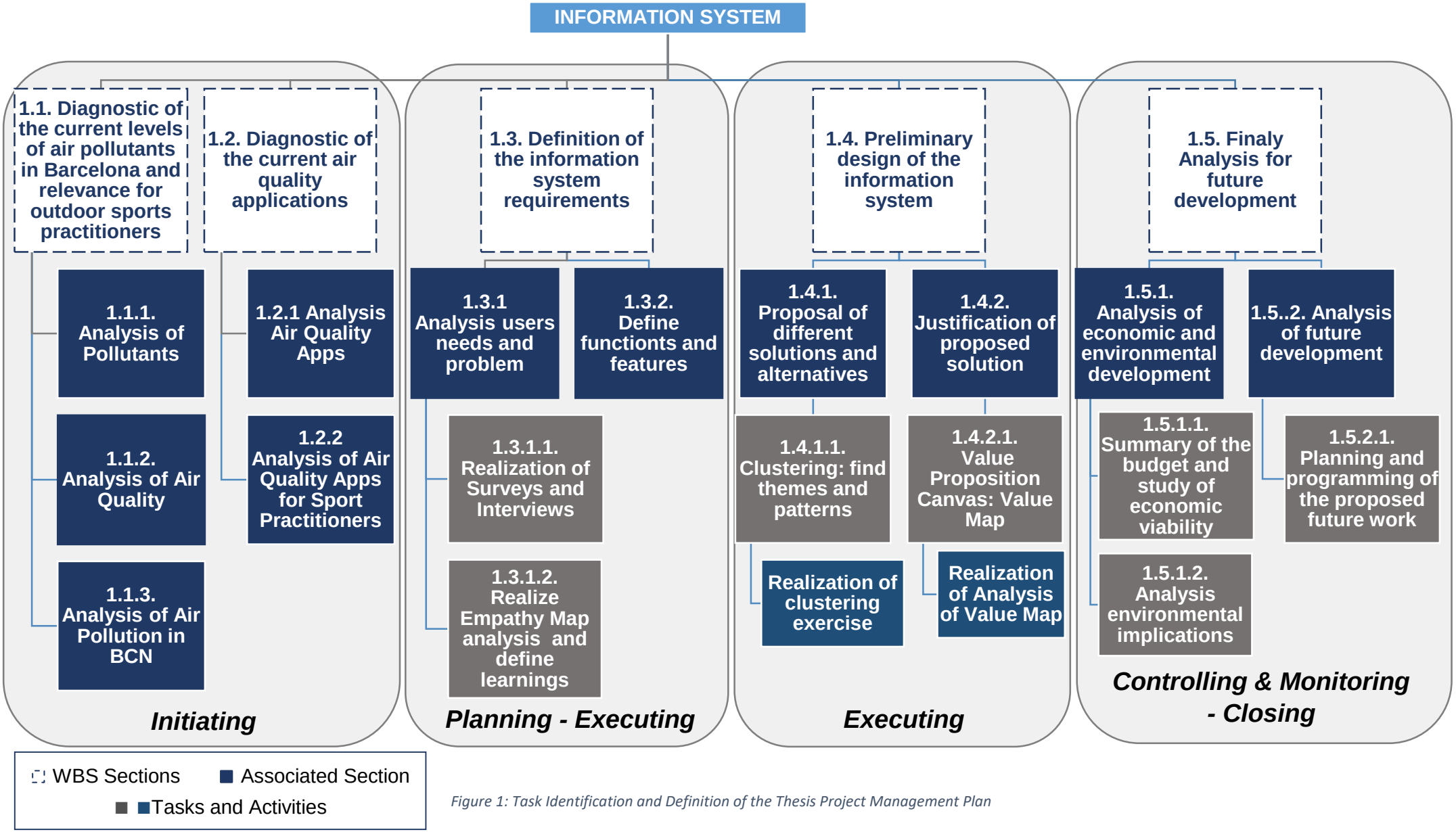


Figure 1: Task Identification and Definition of the Thesis Project Management Plan

3.3 PROJECT PLAN

After setting the goal of the master thesis and defining the scope of it as mentioned in the previous pages, it has been considered to create and action plan or schedule taking into account the main requirements of time and quality. This plan has been carried out for the development of the corresponding tasks to approach our principal aim, which is the project management plan development of a mobile app for outdoor sports practitioners, where they can check the best places nearby to do exercise considering the air quality and other important environmental factors.

3.3.1 PROJECT PHASES DURATION ESTIMATION

First, the activities duration estimation has been calculated considering the different five phases due the amount and complexity of activities defined in the previous chapter.

The planning for the realization of this project consists in working amount between 7 hours daily in the followings months from September to January as is presented approximately in the table below:

Phase	Period	Duration [days]	Duration [hours]
Initiating	19/07/19 – 26/07/19	7	15
Planning	12/09/19 - 27/09/19	15	105
Studying (Background + State of the Art Technology)	28/09/19 – 22/10/19	28	196
Executing (Development)	27/10/19 - 17/12/19	52	364
Closeout (Results Summary)	18/12/19 - 05/01/20	18	126
Total:		120	770

Table 2: Project Phases Duration Estimation

3.3.2 SCHEDULE

Next, a Gantt Diagram has been done which illustrates the project schedule to see in detail the deadlines and how long will take each activity. In the vertical axis the tasks to be performed are listed and in the horizontal axis can be seen the time intervals.
Furthermore, this diagram helps to know the chronological order in which the tasks must take place to approach one after one without missing information in between to be able to complete the next task.

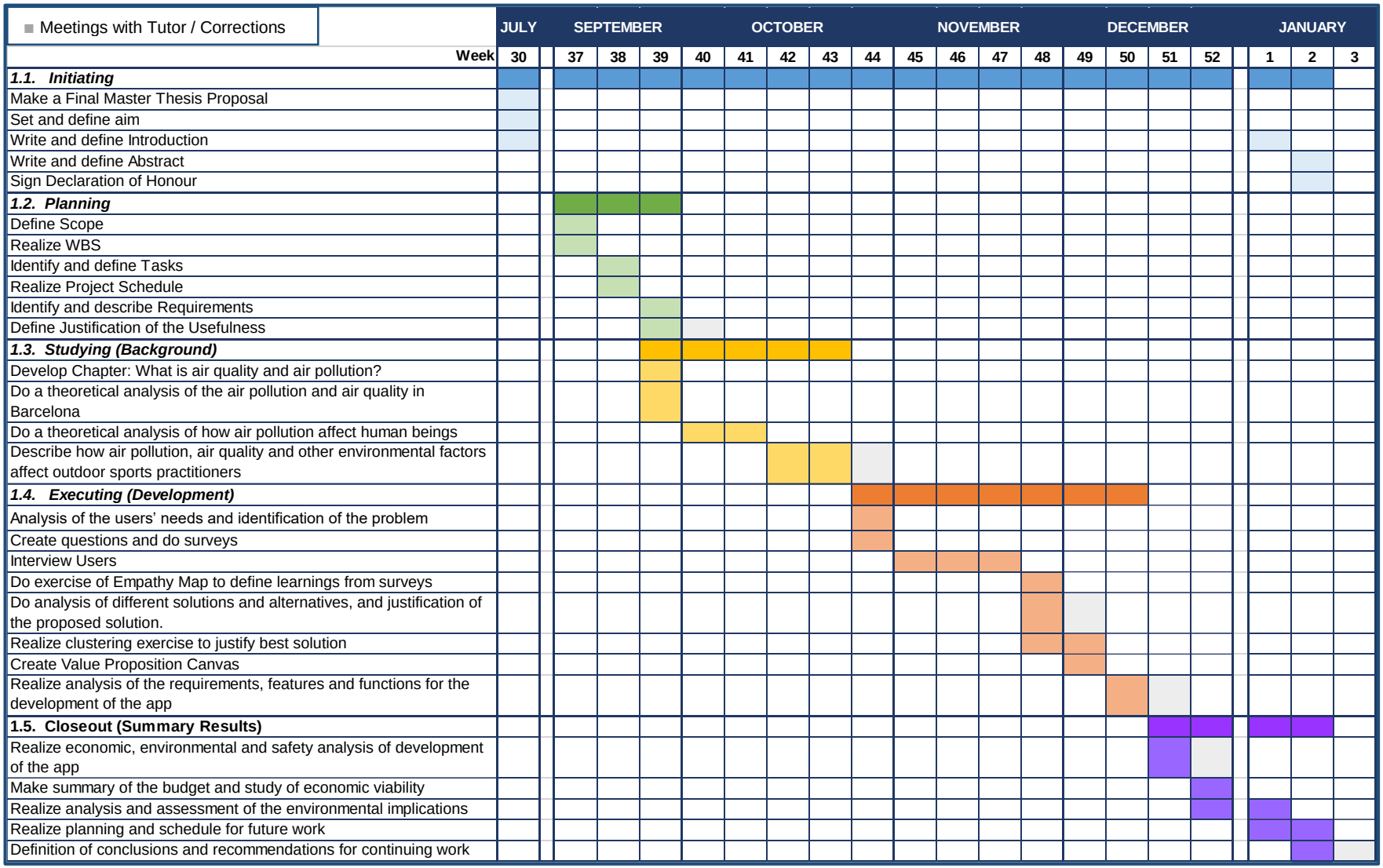


Figure 2: Gantt Diagram

4. REQUIREMENTS

As it was said before in the introduction, in this thesis it has been studied the development of a mobile solution.

The requirements that the app must meet are described:

- The app must be compatible with different digital platforms, as mobile phones, tablets or even computer desktop.
- The app must be available in both operating systems Android and iOS.
- The app must include information interesting not only for sport practitioners, but also other people interested that can be affected in their daily life by the air quality and other environmental factors.
- The app must present and easy and clear looking to be used by people of all ages.
- The app must include data that cover at least one year for the diagnose of the air quality in Barcelona.
- The app must include information on real-time measurements of environmental stations available in Spain.
- Possibility of registration of the user to provide his data and be able to have a more personalized app according to his preferences.
- Weekly Report of future prognostics to be able to schedule your exercises or activities.
- Possibility to create a community forum where the users can know each other's experiences in different places.

5. JUSTIFICATION OF USEFULNESS

As it was mentioned at the beginning in the introduction, sport, environment and health are different aspects that are very related to each other, as according to the environment conditions such as rain, our activities can be placed or for example a poor air quality can affect our health. So, why air quality is so important for human's health? By average and adult breathes around 15000 litres of air every day. When we breathe polluted air, the pollutants get into our lungs where they can enter the bloodstream and be carried to our internal organs such as the brain. This fact can cause severe health problems such as asthma, cardiovascular diseases and even cancer and reduces the quality of life. For that reason, vulnerable groups as children, people with chronic diseases, elderly or even professional sports practitioners are very careful about the air quality index around them.

The solution proposed in this project is a mobile app where anyone can check the air quality index around and other environmental factors and even know if the air its high polluted or not and which activities are not recommended to do in the checked area.

This app can help the interested people in scheduling better their activities as running or even walking or chilling out in a better place or in a better time to prevent to breath contaminated air that can affect negatively their health.

The facility of having an app like this can make such a scheduling activity very easier to the user, he just has to register and select his preferences from activities, timing and area. The app will provide a weekly report according to the app prognostics to the user to practice his activity in the best hour of the established time range chosen and the better area nearest to you. Furthermore, in case of any change in the weather conditions or air quality the app will send a notification to the user.

Moreover, multiple features will be included in the app such as a forum where users can share their opinions about different places that the app recommend them to do their activities, weekly newsletter with general data that can be interested to the users or even recommendations of how to develop some habits to recycle and generate less waste.

6. BACKGROUND

In recent years, major progress has been made as regards the knowledge and understanding which has been gained of the impact of air pollution.

Regardless of its geographical origin, air pollution moves freely around and respects neither city nor national borders. Most often, it is a mix of several pollutants that come from multiple sources depending on the area. Some factors that can affect in the air quality can be the local topography (mountains, deserts, sea, etc.), climate (temperature and humidity) or even weather conditions (sun, rain, wind).

So, big cities with favourable topography, climate and weather conditions, may be better off than smaller cities surrounded by mountains or deserts with high temperature and humidity. In cooler climate zones, the winter season with increased fossil fuel burning for heating, may cause a drastic accumulation of air pollution on days with no wind and stagnant cold air.

However, it is the amount of particles and gases emitted into the air from different sources that constitutes the root cause of air pollution. Consequently, air quality is most often compromised in heavily industrialised areas with large populations.

Currently, a large majority of the world's large metropolitan areas share the problem of air pollution, and large European and Spanish cities are no exception, with high levels of concentration of local pollutants higher than recommended by the World Health Organisation (WHO) and the European Union (EU) itself.

For many different reasons, large urban centres are almost always the location for major sports events such as the Olympic Games, World Championships or World Cups.

From the Olympic Games in Los Angeles in 1984, the air pollution started to being a health hazard for athletes and started to be considered in several major sports events.

In 2008, in the Beijing Games it has been worked to improve the air quality in the megacity before and during the event to be able to host such a large an important event.

The main short-term impact of air pollution on human health range from a rise in the overall death rate resulting from respiratory and cardiovascular diseases to be worsening of lung function and other symptoms, including a rise in the number of doctor visits and hospital admissions related to air pollution issues.

The damage caused to our body by breathing pollution is many, especially if we exercise in polluted areas, since the air quality is not the same as if it were purer. This is why we must be very careful when doing physical activities outdoors, because first we have to know where and how they should be done.

The air is formed by oxygen, carbon dioxide and other particles that are suspended in the atmosphere, such as dust, pollen ... When there is an excess of pollution the quality of the air diminishes, because the concentrations of toxins derived from the combustion are greater. The majority of these are usually produced by the means of transport when they are expelled when the fuels are combusted.

Through this combustion, toxins that end up being harmful to our organism become part of the air. This effect is more accentuated when we do sport, as we consume 20% more air than usual. This is why the harmful effect of these substances is multiplied and with it the formation of free radicals that affect our health.

Some pollutants which affect air quality, such as nitrogen oxides (NO_X) and suspended particulates (PM_{10} and $PM_{2,5}$), among others, are present due the mobility or the industrial and port sector because of the direct impact these activities have on air quality.

Unlike CO_2 and other greenhouse gases that affect the global warming of planet in the long term, local pollutants such as NO_X and PM affect people's health residing or moving in the area near the source of emission.

The respiratory system and the cardiovascular system will be the main ones affected by this excess of pollution, and is that our lungs will be forced to filter an air in bad conditions deteriorating little by little by the accumulation of heavy metals contained in the atmosphere. This process can lead to diseases such as chronic bronchitis or pulmonary diseases between others.

With pollution, our circulation slows down and is not as fluid as it should be. This can cause disorders in our cardiovascular system such as poor circulation, weakness of the arteries and heart, may suffer long-term heart attack or any other type of heart disease.

It is advisable not to practice sports outdoors during the daytime, as the pollution is greater by the large influx of vehicles. If there is no other option, the ideal is to carry out the activity in a park or green area where the air is purified by the trees. In parks the concentration of oxygen is normally higher than in other places.

What is certain is that the ideal moments to carry out the exercise are at dawn and at night, since the levels of contamination have diminished considerably, although if we

have the possibility the best thing is to move away from the city and to carry out the sport activity in full field, because our health will thank us for it.

6.1 POLLUTANTS RELATED TO AIR QUALITY AND THEIR EFFECT ON HUMAN'S HEALTH

As it was said before, nowadays more and more people are moving to metropolitan areas (more than 50% of the world's population), a trend that increases urban growth and the concentration of population and activities economies. These factors also lead to greater air pollution, which is becoming in a public health priority in our cities.

The exposure of living in a city where air quality is below established limits can adversely affect people's health episodically or chronically: it is episodic when the person is exposed to high concentrations of pollutants for a short period of time (hours or days), while for chronic is the cases of permanent and continuous exposure, even if it is to relatively lower concentrations.

The airway is the primary entry point for airborne contaminants and can lead to inflammation or reduced lung function as it was mentioned before. But human health conditions are not limited to the respiratory system, as there are other common effects such as irritation of mucous membranes (eyes, nose and throat, esophagus) or the effects on the cardiovascular system and the worsening of some types of cancer or diabetes, which can shorten the lifespan of people who suffer pollution.

The impact of motorised traffic or industrial activities on the concentration of pollutants is relevant, but it is necessary to indicate that air quality is strongly influenced by the regional contribution and the following factors:

- Proximity of the issuing source.
- Altitude at which pollutants are released.
- Weather conditions (wind, heat, rain, thermal inversion).
- Chemical transformations (reactions to sunlight and interactions of pollutants).
- Geographical conditions of the territory (topography).

Then, in this chapter, we are going to analyse the particulate matter (PM) and the nitrogen dioxide (NO_2), as they are considered to be the most important in terms of their impact on human's health and in terms of concentration in most European cities. Their sources of emission and health consequences after prolonged exposure are described next.

6.1.1 PARTICULATE MATTER (PM)

Particulate matter or suspended particles is a general term used for a complex mixture of particles (solid and liquid) formed by a set of airborne molecules that are one of the pollutants that have the greatest impact on human health, as they penetrate sensitive regions of the respiratory system and can cause health problems in other systems of the human body.

These particles are a decisive indicator in the assessment of air quality. PM can come from many sources and are a complex heterogeneous mixture whose size and chemical composition varies over time and space, depending on emission sources and atmospheric and climatic conditions. They can be from two different origins:

- *Primary origin:* they are emitted directly into the atmosphere from emitting sources, such as chimneys.
- *Secondary origin:* they occur in the atmosphere as a result of chemical reactions involving PM precursor gases (SO2, NOx, NH3) and volatile organic compounds (VOCs).

In the same way, they can be generated by two types of factors:

- *Natural:* those that are emitted without the involvement of the human factor, such as desert dust, marine salts, marine sulphates, volcanic ashes, microorganisms, pollen, algae and insects, among others.
- *Anthropogenic:* those that are emitted by activities in which the human being is involved such as traffic, biomass burning or industrial activities.

Suspended particles are classified according to their aerodynamic diameter: the largest particles are 10 microns thick diameter or less (PM_{10}). However, the most worrying are those with a diameter of 2,5 microns or less ($PM_{2,5}$), a size small enough to pass from the airways to the bloodstream through the alveoli, like oxygen molecules.

In addition, these smaller particles are composed of elements that are more toxic than those that make up, in general, the largest particles, as they come from combustion processes, such as heavy metals and organic compounds.

Thus, there is a direct relationship between exposure to high concentrations of PM and increased mortality in the long run. Permanent exposure to particulate matter contributes to the risk of development:

- Chronic cardiovascular diseases.

- Respiratory problems and irritation in eyes, nose and throat.
- Respiratory system affections: irritation, inflammations, asthma, reduced respiratory capacity, obstructive pulmonary diseases, as well as lung cancer.
- Reproductive system problems.,

In the European Union, the average life expectancy is estimated to be 8,6 months [2] shorter due to the exposure to $PM_{2,5}$ resulting from human activities.

Because of the health implications of these particles, both the World Human Organization (WHO) and the European Union (EU) have established thresholds to be met:

PM	Period	WHO	EU
$PM_{2,5}$	Annual Average	10 µg/m^3	25 µg/m^3
	24 h Average	25 µg/m^3	45 µg/m^3
PM_{10}	Annual Average	20 µg/m^3	40 µg/m^3
	24 h Average	50 µg/m^3	50 µg/m^3

Table 3: Threshold values for PM according WHO and EU [2]

6.1.2 NITROGEN DIOXIDE (NO_2)

Nitrogen dioxide (NO_2), is another of the polluting gases that can have harmful effects on human health and can be found in high concentrations in large metropolitan areas.

NO_2 is a gas consisting of two oxygen atoms and one nitrogen atom. It is reactive and is formed mainly by the oxidation of nitrogen oxide (NO) being the main sources of anthropogenic NO_2 emissions, mainly from combustion processes at high temperatures (heating, electricity generation and engines of vehicles and ships). The amount of NO_2 emitted depends on the combustion conditions and the quantity and type of fuel burned.

In relation to health effect can even be caused by short-term exposure to NO_2 at concentrations of greater than 200 µg/m^3 [3] as it causes significant inflammation of the respiratory airways and changes in lung function in vulnerable groups of population.

More continuous and long-term exposure is associated with susceptibility to respiratory infections and irritation of the eyes, nose and throat. In addition, prolonged exposure to NO2 is associated with increased symptoms of bronchitis in children and decreased pulmonary development, as well as effects on the blood system.

The values set by the WHO and the EU are the following in Table 5, this information will be needed to know the maximum NO2 recommended in air to be able to set the app to this average.

	Period	WHO	EU
NO_2	Annual Average	40 µg/m^3	40 µg/m^3
	1 h Average	200 µg/m^3	200 µg/m^3

Table 4: Threshold values for NO_2 according WHO and EU [3]

6.2 AIR QUALITY EFFECTS ON OUTDOOR SPORTS PRACTITIONERS

Nowadays, most experts in the field focus on the effects of pollutants on the overall population, with emphasis on more vulnerable groups such as children and the elderly, with some references to the general practice of sport in urban areas.

The practice of sport in an urban environment, implies a longer time of direct contact with local pollutants, as well as a higher inhalation of air due to the physical activity itself. So, the major sport affected in this case is running as it's outdoor and the physical activity done make the practitioner to inhale higher amount of air.

In this case, this increased exposure may raise some questions among the runner collective as for example:

- Is it healthy to go out to train in the city?
- If you live in a big city, is it better not to go running?
- What is the difference between running in an urban environment or training in a green area?
- Do I have to take any precautions?

To answer these questions, the search on the web often brings disparity of opinions and positions on these issues.

On the contrary, it is becoming easier and easier to access public information on air quality indices in real time from pollutant measuring stations, although these indicators are not representative of the whole city, with deviations of more than 50% in some cases.

6.2.1 POOR AIR QUALITY DIRECT EFFECTS ON OUTDOOR SPORTS PRACTITIONERS

Physical activity increases the rate of breathing and during physical exertion can be multiplied by 40 the ventilation, a respiration that is usually done through the mouth. As a result, the amount of pollutants inhaled also increases considerably. [4]

The effects of these overexposures can be considered in the short term and have also been studied in the long term.

- *Short-term* exposure can lead to lung problems such as inflammation of those parts of the lungs through which nitrogen oxides circulate when breathing, especially if the air is inhaled through the mouth, as the natural filter of nose hairs and mucous membranes is lost, as well as those of the nose particles access the lungs directly down the throat.

Some more common effects, if any of high pollution situations, are often the feeling of lack of air intake on a regular basis and the ringing in the ears.

Does it affect everyone equally? People with recurrent training and who do not force their body during physical exercise have less need for mouth breathing, so the impact in these cases is lower. It can be specified that the way of breathing and other related factors, such as physical condition, age and usual behaviours (work, smoking ...), can cause affects due to pollution.

So, to reduce the impact of pollutants on health during sport, it is advisable to breathe through the nose, which acts as a natural filter.

- In the *long term*, there is an interaction between physical activity and air pollution. In particular, controlled studies of real-life exposure have been carried out that have detected a high level of reduction of lung function associated with the practice of activities that require some physical exercise (running near the heavy traffic of a main road or riding a bicycle during peak hours) in a urban environment with high concentrations of local pollutants; in this case, in a busy street of a big city In the long term, there is an interaction between physical activity and air pollution. In In particular, controlled studies of real-life exposure have been carried out that have detected a high level of reduction of lung function associated with the practice of activities that require some physical exercise (running near the heavy traffic of a main road or riding a bicycle during peak hours) in a urban environment with high concentrations of local pollutants; in this case, in a busy street of a big city like London.[3]

On the other hand, there is no study which has concluded that an exposure to air pollution modifies the beneficial health effects of physical activity, without any direct effect on the health of the patient.

6.2.2 DISTANCE BETWEEN THE EMITTING FOCUS AND THE ROUTES THROUGH THE URBAN GREENERY

Another relevant aspect to consider is the distance to the source of pollution and the barriers that separate the runner's route from the roadway where the vehicles circulate, in the case that the emitting source is land transport.

The pollutants that affect air quality affect people at the same point where they have been emitted and, therefore, the distance from the focus of emission has a direct relationship with the quality of air that is breathed. So, considering some projects indicate that just one metre away from the roadway can reduce exposure to pollutants by 15%, and that changing from one high-traffic street to another with hardly any traffic can result in a reduction of more than 60%.[5]

The presence of vegetation is positive thanks to its barrier effect between the emission focus and the runner's training itinerary. Exposure to pollution is substantially lower in the case of hedges, so that in some cities they are already applying plant barriers to limit the effects of traffic on pedestrians and possible runners.

On the other hand, urban green can also become an element that prevents the dispersion of pollutants in the case of trees in narrow streets with tall buildings, a common urban typology in the Spanish city of Barcelona.

6.2.3 COMPARISON BETWEEN SEDENTARY LIFE AND SPORT PRACTICE

Despite the problems posed by exposure to air pollution, there is a broad scientific consensus advising the regular practice of sporting activities, whether running, cycling or even walking.

The existence of moderate levels of air pollution is not contraindicated with outdoor sports. The benefits of sport have been shown to outweigh the potential harms of exposure to poor air quality.

Physical activity plays a key role in improving physiological mechanisms and activates the release of multiple substances in the body, as well as hormones that stimulate the immune system. This reality presents a possible contradiction between the beneficial effects of physical activity in the urban environment and the harmful effects of air pollution on health.

By inhaling pollutants, the body suffers damage and inflammation, but exercise has the ability to compensate for this negative impact. In addition, it should be borne in mind that sedentary lifestyle is a more important cardiovascular risk factor than smoking, hypertension, diabetes or exposure to local pollutants such as NO_2 or PM in the air.

To sum up, it can be said the that the engaging in activities that require physical exercise on the public highway, such as running, cycling or any outdoor activity, is associated with lower mortality, which is not significantly modified by exposure to NO_2 in an urban environment: the estimated benefits of sporting activity on respiratory mortality were slightly reduced, but were not nullified for those living in areas with high levels of NO_2.

In general, the long-term benefits of physical activity in terms of reduced mortality outweigh the risk associated with increased exposure to air pollution during physical activity.

In this regard, it would only be recommended not to engage in sport on days of pollution episodes to the most vulnerable population as children and the elderly, or any person suffering from heart or respiratory diseases.

7. ANALYSIS OF AIR QUALITY MOBILE APPLICATIONS

Before starting the design thinking process were are going to be identified the requirements and needs of the users of the information system, first it has been done an analysis of the current existing apps in relation to controlling air quality around for all publics in Barcelona and also worldwide.

Furthermore, it was also analyzed other specific apps for runners or general outdoor sports practitioners to check different environmental information that will be similar to the information system which will be developed but considering to apply new technologies and information not available in the present apps in the market.

7.1 GENERAL AIR QUALITY MOBILE APPLICATIONS

As it has been said before, nowadays, the quality of air we breathe has begun to be a concern for people worldwide for different reasons as having a respiratory illness like asthma, want to do sports outdoors or even just to go with the children to the park.

In all these different situations there are people who are interested to know the air quality in their near areas to decide to develop their activity or just postpone it when the air quality is better. So, in the era of technology, there are already existent technologies to know the levels of pollution practically in real time, but we will present just the different ones that present a relevant feature or function.

- ***CALIOPE:***

The Center of Supercomputing of Barcelona (BSC) together with the Ministry of Agriculture, Food and Environment, developed an air quality forecasting system called CALIOPE, which since September 2007 offers the forecast of air quality for the European Union and Spain with predictions at 24 and 48 hours.

In 2013, the BSC developed the CALIOPE app for iOS and Android with forecasts for Spain, and in 2015 it has officially presented the CALIOPE EU app for forecasts in Europe.

Figure 3: Caliope App First Page Screenshot

The differential element of CALIOPE is its *predictability*. Other apps with information on emission levels are limited to providing information on real-time measurements of environmental stations available in Spain, Europe or the world. The CALIOPE system uses a predictive model that allows predicting the level of contamination up to two days in advance, which is vital in decision making for both users and municipal or state agencies.

- ***AireCat*:**

This is an app provided by the Generalitat of Catalonia were it is possible to know the air quality in Catalonia and consult the forecast of the air quality planned for today and for the next few days.

Also you can receive notifications about the activation of pollution episodes with the information you are interested in filtering by area and by contaminant.

Other applications that provide similar information but in different platforms which are available worldwide are for example Air Matters and AirVisual.

Figure 4: AireCat App First Page Screenshot

- ***AirACT:***

AirACT is an app developed by the Polytechnic University of Catalonia in collaboration with Ecologists in Action, the Higher Council for Scientific Research (CSIC) and Guifi.net within the framework of the European CAPTOR project. With it we can know from the mobile the levels of the main air pollutants and, perhaps most importantly, what is the level of risk to which we are exposed.

Because unlike other applications, AirACT alerts have been established based on WHO and EEA recommendations, giving them an alert range divided into four colors.

From the application we can consult the data of the control station closest to the area that we select on the map or check the levels of a specific pollutant. The app shows the current information available for each station, but also allows you to know the history of the recorded values. For this, it is enough to indicate the desired period of time and the screen will show a very pleasant and understandable infographic in which we can check the days or hours in which the values exceeded the recommended margins.

In addition, you can consult the effects on our health and the environment of each pollutant, as well as a series of practical tips so that we citizens can contribute to alleviate pollution and mitigate its effects.

7.2 AIR QUALITY MOBILE APPLICATIONS FOR OUTDOOR SPORTS PRACTITIONERS – BENCHMARK COMPETITORS

As it has been seen in the previous chapter, nowadays there are a lot of air quality apps that show you the index of the air quality at the real time, the prediction until two days after, or even notifies you when there is a period of poor air quality nearby.

However, our project is related to an information system for outdoor sports practitioners to check the air quality and other environmental factors that can may affect their activities or health, so for that reason it was also checked which apps are available in the market and which features they present.

- ***Plume:***

Plume is a very detailed app that comes from France. The users are ableto choose to share their location or just search for an certain city and check the air quality and other environmental factor. A cartoon cloud with different expressions according to the weather and air quality of the city, so that is what makes it attractive.

Figure 5: Plume First Page Screenshot

An interesting feature that the application presents is by scrolling down to play with the curve which is a graph running along the bottom of the screen that represents the air quality index in all the next 24 hours.

Something else, are the four icons representing different activities that will change their colour according to the level of the air quality index and indicate if it's recommended or not to do this certain activity. Finally, an interesting feature is that the app has a social aspect where users can add current air quality levels to photos and share them.

- ***BreezoMeter App:***

BreezoMeter it is an easy and intuitive app that help you check an index of ambient air quality in real time, in your specific location, as simple as checking the weather.

This app allows you to adjust the level of sensitivity of notifications on changes in air quality depending on whether you have children, like to exercise outdoors or if you have respiratory problems.

Furthermore, it includes real-time air quality maps, where you can see with your own eyes how the air quality looks in your street, neighbourhood and even across the country.

In the other hand, BreezoMeter also presents health recommendations for taking personal actions such as know what you should do, whether at home, to look for a route to exercise, plan a trip or take care of the children.

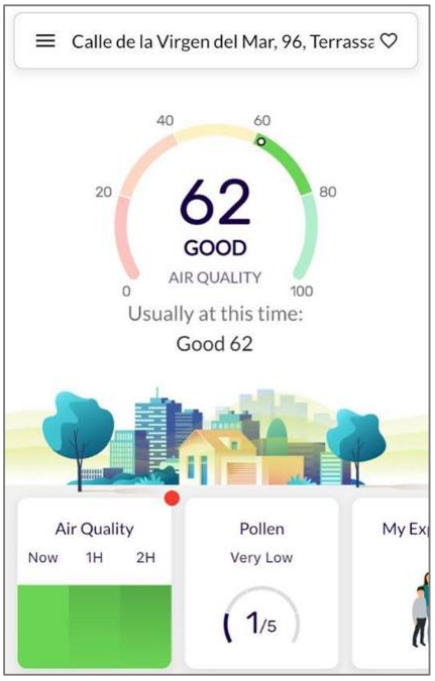


Figure 6: BreezoMeter App First Page Screenshot

As it has been presented, all these different apps which had the same aim which is to provide their users the data about the air quality index nearby. However, they not only present the same aim, but they differ in multiples ways as the many different functions and features they present one from one.

So, before defining the requirements of our information system by interacting with users and know their needs it was interesting to do an analysis of all the different features that each of those previous apps present. The reason of this analysis is to try to identify which are the missing features that can be applied in our information system and which features and functions which can be applicable for the app we want to develop considering outdoor sport practitioners and which data will be different to enrich our unique and different application.

7.3 AIR QUALITY MOBILE APPLICATIONS COMPARATIVE

In Table 5 it can be seen a general comparative between the most characteristics features present in the different air quality mobile apps presented. As a result, it can be said that the most completes applications are Air Visual and Plume. However, both apps are not made specially for sports practitioners and there is a lot of features missing that can be useful for sports practitioners and fulfil their requirements, as for example, having a report of the best timing to practice their sports or even a list of the bests areas around for going for a run.

	Caliope	AirACT	AireCat	AirMatters	AirVisual	Plume	BreezoMeter
Air Quality Index in real time	✓	✓	✓	✓	✓	✓	✓
24h Forecast	✓		✓	✓	✓	✓	✓
48h Forecast	✗		✓	✗	✓	✓	✗
Zone Map / Stations	✓		✓	✓	✓	✓	✓
Worldwide Map / Stations	✗		✗	✓	✓	✓	✓
Emissions by Pollutant	✓		✓	✓	✓	✓	✗
Other environmental information (weather, allergies, pollen…etc)	✗		✗	✓	✓	✓	✓
Air Quality Index and information related to different activities (sports, walk or chilling)	✗	✗	✗	✗	✗	✓	✗
Notifications in case bad air quality episodes according to personal profile adjustments	✗	✗	✓	✓	✓	✗	✗
Availability for Android & iOS	✓	✗	✓	✓	✓	✓	✓

Table 5: Air Quality Mobile Applications Comparative

EMPATHIZE

DEFINE

IDEATE

PROTOTYPE

TEST

DESIGN THINKING PROCESS

8. DESIGN THINKING PROCESS

After introducing what is air quality, how is it in the city of Barcelona and how it affects humans being health taking into consideration outdoor sports practitioners, it was understood the problem that some users can face while doing a simple activity of going running in the wrong period of time or in a polluted area where they will breath an air with a poor quality.

According to the proposed solution the last analysis of the comparative of the mobile applications it has been done to be able to create an application that is totally complete with all the previous features available in already existing applications and add new features and functions to add value to our new application.

Therefore, for starting the development of the proposed solution that is in the next pages, it has been chosen the "*Design Thinking"* methodology, which is a human-centred approach to innovation that draws from the designer's toolkit to integrate the needs of people and find desirable solutions for clients. For completing the design thinking methodology, the process followed is the next presented in the figure below:

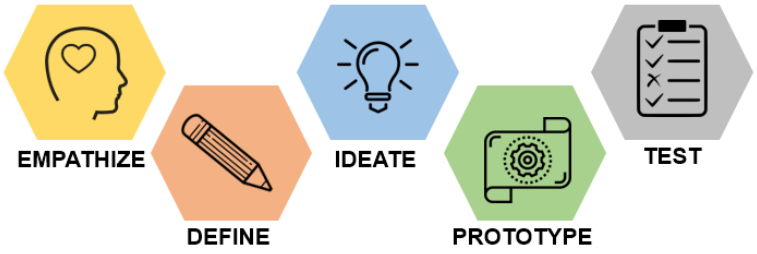


Figure 7: Design Thinking Process

As it is seen, the Design Thinking Process it's complete by different five phases:

- **Empathize:** to empathize with the users to understand their problem.
- **Define:** definition of the problem the users face.
- **Ideate:** propose solution with functions and features that fulfil the user's requirements.
- **Prototype:** create proposed solution in the easiest way possible.
- **Test:** check and verify if the prototype fulfils the user's requirements and the environmental, safety and socioeconomic impact.

8.1 1st PHASE: EMPATHIZE

The first phase of the Design Thinking is to Empathize, so first we must understand and describe what is it about the "*Process of Empathy*".

This phase involves developing a sense of empathy towards the people we are designing our product for, to gain insights into what they need, want, behave, think, and why they demonstrate such behaviors, feelings, and thoughts when interacting with products in a real world setting.

Furthermore, we should try to imagine ourselves in these users' environment, in order to gain a deeper understanding of their situations which will allow us to gain empathy towards the users. However, to really gain empathy towards people, we have to observe the users in their natural environment passively or engage with them in interviews and both will be the methods used in this phase.

8.1.1 METHODOLOGY

The methods used to empathize with the users are the described next:

- **General survey:**

The first method used is not to empathize with the main users, but to know the pains, gains, opinions and suggestions of surrounded people with general questions related to get to know how much important they think it can be the app, and how much people can need it and use it to justify the need of our solution.

- **Interview with usual outdoor sports practitioners:**

The second method consists in a personal interview face to face to different sixteen people who usually practice sport outdoors. The main goal of this interviews is to be able to understand which difficulties related to environmental factors this people find while practicing their sports.

The first part of the interview are direct questions to the users while the second part consists in letting the user discover the application of Plume and give their main opinion and suggestions while analyzing their reactions, feelings and behaviors.

8.1.2 OBJECTIVES

So, after the description of the two methods of empathy with the user, it defined the main objectives of the research and what do we need to learn from the general survey and the more the interviews.

- From the general survey, the main objective is collecting as much feedback as possible from possible future users regarding what features should the app cover in order to make their life easier and be able to anticipate needs.
- In relation to the interviews, the main objective defined is to find out if there is a necessity for outdoor sport practitioners to consider environmental conditions being the air quality the main important or is not even considered and do not cause any difficulties. If not, would the users be interested and willing into have an app that can helps them to manage better their schedules considering the environmental factors?
- As an outdoor sport practitioner, which difficulties you face when you make a plan for practicing sports and the weather is not helping or even the air quality is not the best?
- As the project goes by, see if the data will be in some way useful both for profit and investigations purposes.
- Identify the main interesting features in the Plume app, which features are missing, and the main needs of the users.

8.1.3 IDENTIFICATION OF THE USERS

Another important issue to consider after the objectives is the definition of the users, which kind of users we are interested to empathize with, considering different profiles to interview and to reach with the survey.

- **General survey:**

This survey is indicated for all the possible profiles that we can reach, even if they don't practice sports usually and have a sedentary life. The main issue from this survey is to know the importance of the air contamination in our society and how much important is according to sex, ages, sedentary life or more active or even any other factors that can be discovered through the survey.

- **Usual outdoor sports practitioners (interview) - 16 people**

SEX	AGE GROUP	SPORT	FREQUENCY	AGE
FEMALE	18-24	Running (Athlete)	5 times / week	23
		Cycling	3 times / week	24
	25-34	Swimming / Running	5 times / week	26
		Running (Athlete)	5 times / week	32
	35-44	Cycling	2 times / week	36
		Aerobic / Running	3 times / week	42
	45-60	Running	3 times / week	47
		Cycling / Running	5 times / week	57
MALE	18-24	Running (Athlete)	5 times / week	19
		Hockey / Running	5 times / week	24
	25-34	Water polo / Running	3 times / week	28
		Running (Athlete)	5 times / week	33
	35-44	Running	3 times / week	36
		Running	3 times / week	44
	45-60	Running	3 times / week	53
		Cycling	2 times / week	60

Table 6: Identification of usual outdoor sports practitioners interviewed

As it can be seen, the profiles chosen are quite varied and balanced. For the interviews, 8 women and another 8 men with different averages of ages were questioned. The variety of sports presented are between cycling, swimming, aerobic, hockey, water polo and running, being this last one the most popular which can benefit us, as it's the most affected sport by air pollution.

An important issue to value in those profiles are the frequency of practicing their sports and as it can be seen all of them are very constant by practicing their sports which indicated that they are usual sports practitioners.

8.1.4 GENERAL SURVEY: HOW DOES AIR QUALITY AFFECT OUR HEALTH?

To know how much people are aware about air quality and how much they think outdoors sports practitioners can be affected by this factor a survey was send it to them.

The survey was created by the platform of Google Surveys which facilitates the creation of it and make it easy to share via What's App groups and email to family, friends and colleagues and save their answers.

The survey was composed by 17 questions that were asked strategically to take a specific information from each question. Next, the questions asked are presented with the main objective from each question. Thus, is presented an analysis of the results obtained from the 104 answers registered in 5 days from the 9th of December 2019 to the 13th of December 2019.

- ***Title:*** *HOW DOES AIR QUALITY AFFECT OUR HEALTH?*
  - *Objective:*

    The title presented in the survey was to take the attention of the reader but giving them a hint that air quality can affect our human health and make it interested to follow to be able to know how.

- ***Description:*** *Hi everyone, first of all thank you for the time you are dedicating to me, helping me out with my Master Thesis.*

  This survey is used to know how aware is our society about air pollution and how does it affect human being's health.
  - *Objective:*

    This short and precise description was created to make the user know the main objective of the survey they are taking their time to answer and to thank them for the inverted time by answering.

- ***Profile:*** *Gender and Age*
  - *Objective:*

    These questions were made to know the profile of the people and analyse their answers according to their age group or gender.

- *Results:*

  The answers registered were from 56 women and 48 men.

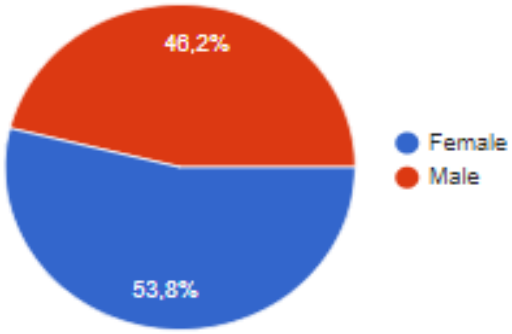


Figure 8: Gender percentages of the population that participated in the interview

The interval of ages of the people who answered is presented in Figure 9, it can be seen that the half of the answers come from people between the age of 18 to 24 years old.

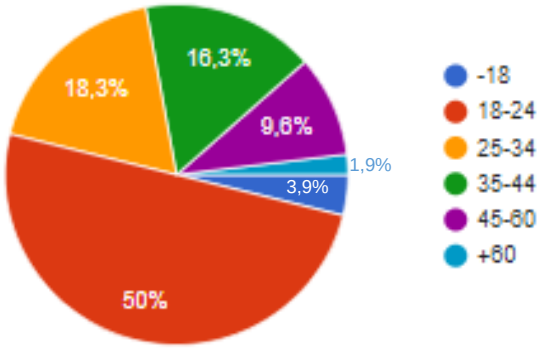


Figure 9: Age Intervals of the population that participated in the interview

- ***Question 1*: *Do you think you are concerned about air quality?***
- *Objective:*

  The intention of this questions was to know which is the perception of the people of being concerned about air quality or they feel they need more information.
- *Results:*

  For this question, the 67,3% of the answers were affirmative, so the majority feel that they are concerned about air quality. Thus, considering that there is an important percentage of 24% who feel that they are not sure about it.

- ***Question 2:** How does air quality impact your health?*
- *Objective:*

  This question was made to know if the people answering know which health problems can cause air quality in humans.
- *Results:*

For this question the 92% consider both options of:

- Development of diseases: asthma, bronchitis, emphysema or even cancer
- Symptoms of respiratory illness,

While only 6% are aware about Symptoms of cardiovascular illness, and 2% consider acne and not being psychologically comfort in the city where do they live due the air pollution.

- ***Question 3:*** *Are you or do you have any familiar diagnosed with any of these health conditions that make you particularly susceptible to environmental problems?*
  - *Objective:*

    This question was made to know if any of the people who answered or their familiars have any direct health problem related to air quality and how can influence their answers as having probably more information.
  - *Results:*

    For this question the 25% of the answers were affirmative, so we might expect that this percentage might have more information about how air quality can impact our health.

- ***Question 4:*** *If you answered Yes to the previous question, what were you diagnosed with?*
  - *Objective:*

    This question was made to know the more popular air quality health problems between the people who answered the survey.
  - *Results:*

    For this question 94% were diagnosed with asthma, while the 3% bronchitis, the 2% allergies and the 1% left with lung cancer due air pollution.

- ***Question 5:*** *Choose the three most susceptible to severe health problems from air pollution.*
  - *Objective:*

    The objective of this questions was to know by the answers of the people which are the main three groups of people who they think they are more susceptible to severe health problems from air pollution and how is the percentage of people who think about outdoors sports practitioners.
  - *Results:*

The groups more susceptible to severe health problem according the answers are presented following according to the order of severity:

- Individuals with respiratory diseases (96%)
- Pregnant women (92%)
- Children under age 14 (85%)
- Individuals with heart diseases (82%)
- Athletes or any sports practitioners who exercise outdoors (75%)

According to the answers, it's can be seen that athletes or sports practitioners who practice outdoors even if they are the last group, they still a group with an important percentage of 75% who demonstrate that people are aware about air quality while doing sports outdoors.

- ***Question 6:*** *Please express how much do you agree or disagree on the following statements.*
  - *Objective:*

    This question presented different statements related to air pollution and its intention was to know how concerned and also implicated where the people about different issues.
  - *Results:*
    - "Power stations and factories should switch to cleaner processes even if consumer bills and prices have to go up."

      For this statement, 84% were agree while the 13% undecided and the rest not agree. With those answers we can see that the majority wants to face air pollution even if they have to pay more in their bills.

    - "Government should do more to promote and encourage a better environment even if our taxes have to go up slightly."

      For this sentence, 89% were agree while the 10% undecided and the rest not agree. So, it can be concluded that people think that the government should do more effort to face air pollution and they will follow it even if their bills increase.

    - "Police should stop and check car emissions more frequently."

      For this statement, only the 55% were agree while the 40% disagree and 5% undecided. The answers obtained were quite different due the situation is living Barcelona nowadays by the implementation of the new system of not having access to the capital to old cars due their CO_2 emissions. This

new system made a lot of people feel forced to change their cars or even use transport public, so for that reason they may not accept to be stopped by the police and check their car emissions.

- "Improving the environment is the responsibility of every citizen."
  For this sentence, 97% of the answers were agree. So, it can be concluded that the society knows that each citizen should take actions to improve the environment and is not only responsibility of the government.

- "Recycling programs should be put in places and promoted across the whole city."
  For this statement, also the 97% of the answers were agree. So, more people would recycle if there is recycling programs promoted across the whole city.

- "The pollution is out of my control and I cannot do anything to change it."
  For this statement the 65% where totally disagree, while the 32% undecided due not feeling having all the responsibility but also the government should implement strategies to decrease the pollution.

- "I do not see the pollution as a problem."
  The 80% of the answers were disagree, which means that the majority are aware about pollution being a problem. While, the 15% still undecided and can't consider if air pollution is a real problem or not as they still may not feel affected directly.

- "If I knew how to better contribute to cleaner environment, I would take action."
  For this sentence, the 92% of the people would like to contribute for a better environment in case they know how to do it, so it would be interesting that government promote several programs to encourage this people to take actions that can improve our environment.

- ***Question 7:*** *Which level of air pollution do you think can be present in Barcelona?*
  - *Objective:*
    This question was made to know the perception of the people about the air pollution in Barcelona.
  - *Results:*

The 70% of the answers consider Barcelona with a high level of air pollution while the 30% considerate moderate.

According to the council of Barcelona the level of air pollution is considered low-good. However, according to the answers it's can be concluded that the people feel that Barcelona is more polluted due the actions and the new implementations is taking the government and the impact it's having on them.

- ***Question 8:*** *What do you think are the three main causes of air pollution in the city of Barcelona?*
  - *Objective:*

    The intention of this question was to know which are the three main causes of air pollution in the city of Barcelona according to the people who answered.
  - *Results:*

    The main causes of air pollution in Barcelona according to the answers are the following:
    - Industrial manufacturing facilities (96%)
    - Motor vehicles (95%)
    - Waste disposal (84%)
    - Burning of waste (83%)
    - Construction (72%)
    - Population growth (41%)
    - Large ships in the port (37%)

    According to the answers, it's can be seen that there are several options, but industrial manufacturing facilities, motor vehicles and waste disposal are considered the main three causes of air pollution in the city of Barcelona.

- ***Question 9:*** *In which time of the day you think there is more pollution present?*
  - *Objective:*

    This question was made to know how aware are the people about the time with more air pollution and make them think that can be affected also about the time.

  - *Results:*

    The results obtained are the following:

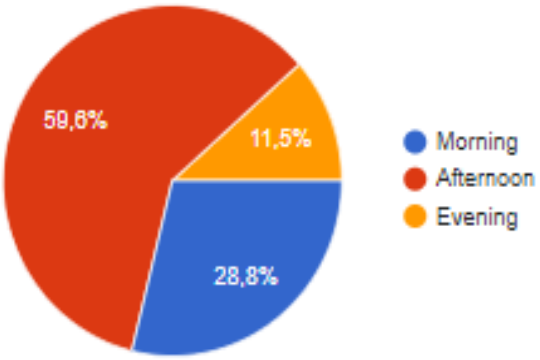


Figure 10: Results Question 9

According to the World Health Organization, the time where is more pollution present is in the afternoon. So, almost the 60% of the answers were right.

- ***Question 10:*** *Do you think air contamination can affect outdoor sports practitioners?*
  - *Objective:*

    This was a direct question to know if the people who answered the survey think that air contamination can affect outdoor sports practitioners or not.
  - *Results:*

    The 95% of the answers were affirmative while the other 5% were not sure. So, it can be concluded that society are aware about the fact that air contamination can affect human's health while practicing sports outdoors.

- ***Question 11:*** *How often do you practice sports outdoors?*
  - *Objective:*

    This question was made to know how often the people who answered the survey practice sport outdoors to know if they can be considered constant sport practitioners that can be affected by air quality or not.
  - *Results:*

    For this question we find out that 74% of the people practice sports outdoors while the other 26% have a sedentary life.

- ***Question 12:*** *Which sport do you practice outdoors?*
  - *Objective:*

    This question was made to know the kind of sport to be concerned about the percentage of running and cycling practitioners who are the most affected by air quality.

- *Results:*

  According to the people who practice sports outdoors we obtained:

  - Running (48%)
  - Cycling (10%)
  - Football (7%)
  - Climbing (6%)
  - Boxing (2%)
  - Aerobic (2%)

It can be seen that the majority practice running which is our main focus sport as it's the one which face the most air pollution.

- ***Question 13:*** *Do you think air pollution or any other environmental factors can affect your sports routines?*
  - *Objective:*

    This was a direct question to know the perception of the people about air quality or any other environmental factors by affecting their sports routines.
  - *Results:*

    The 83% of the answers are aware about being influenced by environmental factors that can affect their sports routines.

- ***Question 14:*** *If there is an app that can provide you environmental information to plan your sports routines and best green areas not polluted do you think you will use it?*
  - *Objective:*

    This question was to make the user know about the kind of app that it wants to be implemented and to know if they will be interested in using it or not.
  - *Results:*

    The 72% of answers were affirmative while 18% were not sure, which can let us know that the app may have a good acceptance from the public.

- ***Question 15:*** *Which environmental factors would you like to be implemented in the app?*
  - *Objective:*

    The intention of this question was to know which information would the user find interesting to have in the app.

- *Results:*

  The 94% of the users will be interested in implementing the weather and air quality index.

  While the rest there is a variety about features like best practices, less populated places, traffic and air quality maps

- ***Question 16:*** *Which features would you like to be implemented in the app?*
- *Objective:*

  In this question, different features where presented to check which ones the public find more interesting to be implemented in the app.
- *Results:*

  The 75% of the answers would like to implement the following features:
  - Best environmentally sport areas around
  - Areas ranked by users (reviews)
  - Personal planning of sports routines adapted to your free hours

  The 25% rest would like to implement different features like:
  - Information about how air quality affects human's health
  - General air pollution information not related to sports
  - Post-workout information
  - Group chat

After analysing these answers it's can be seen which features are more interesting to implement in our app, thus is not only about methodologic features is it also about information as according to the answers it feels like people would like to be always informed and feel more secure about the source of information they have.

- ***Question 17:*** *Would you like to give any suggestion to be implemented in the app?*
- *Objective:*

  This was an open question to be able to know other interests that the users may have and would like to share to be implemented in the app.
- *Results:*
  - Develop a smartwatch sync.
  - Develop a group chat.
  - Best time for practicing sports according air quality.
  - Calendar with air quality history for the last few days or weeks.

- Weather information and humidity level.
- Notifications and alerts according your interests.
- General daily recommendations related to improve the environment.
- Forum to share healthy and ecological recommendations.
- App that everyone can benefit from, not only sport outdoors practitioners.
- Newsletter or blog that talks about pollution, climate change and best practices to improve the environment.

8.1.4.1. CONCLUSIONS FROM THE INTERVIEW ANSWERS

After considering the results analysis done to the answers obtained from the survey, several points have been concluded:

- People with health problems due air contamination are more present in our society than years ago. According to the results 25% of the answering people know someone diagnosed with respiratory diseases or even illnesses.

- The main three groups susceptible to severe health problems according air pollution are considered people with respiratory diseases, pregnant women and children. However, it follows by people with cardiovascular diseases and outdoors sports practitioners. So, we can conclude nowadays people are aware that also sports practitioners can be affected by poor air quality.

- The majority of people wants the government to promote more a better environment by implementing new methodologies even if it means a slightly increase in their bills as the majority see the air pollutions as a big problem. However, according to the answers is not only about the government, the citizens also seem to be aware to implement new methodologies to improve the environment as well in case they are encouraged and well informed to take the right actions.

- Population feel that the city of Barcelona has a high level of air pollution while it's low-good. It can be seen the effect caused on people due the last new car circulation system implemented in the country. For that reason, it can be seen that people consider the motor vehicles the main cause of air contamination.

- According to the answers, it can be seen that people are aware about that air pollution can affect outdoors sports practitioners and their sports routines. So,

the use of an app that can helps to avoid poor air quality it seems to be welcomed. Considering the multiple features that were suggested to be implemented in the app, it seems that people would like to have more information about air contamination and how to prevent it and also some features shows the interest of the users in the app to be able to use it in an efficient way.

8.1.5 INTERVIEW FOR OUTDOOR SPORTS PRACTITIONERS

In this chapter, the template of the interview is presented below with the corresponding questions. The answers of each interview done can be found in the Annex.

The 16 interviewed people were chosen by knowing their interests in sports. Some of them were friends, family members and colleagues at work. The majority of interviews were done face to face even some with Skype due the timing schedules. The interviews were done in different days and places, starting from homes, coffeeshops or even at work.

The structure of the interview started with a brief description of the objective of the interview and explaining to the interviewed person about the idea of the app to develop and the different phases of the interview.

The first phase of the interview was composed by 10 questions which were asked to get general information about which sports may the person practice, for how long they practice, which schedule they have, if they have difficulties due environmental factors to practice their sports and general information to get to know how much is the person involved in sports and considering environment due their activity.

The second phase consisted by analyzing the interaction of the user with a similar app and ask them 4 questions related to the app to get to know their perception and favorite features about it.

INTERVIEW FOR OUTDOOR SPORTS PRACTITIONERS

Age: ***Nº:***

Gender: ***Date:*** *XX/XX/XXXX*

Good afternoon, first of all thank for the time you are dedicating to me, helping me out with my Master Thesis. As may you know, in my project I am trying to develop an App which gives you the possibility to find the best place, time and planning for practicing your favourite sports outdoors considering some environmental factors being air quality the main focus. Thus, the idea is that the app can provide you different suggestions according to your specific registered profile and you can choose the best option to you according your main needs as for example, taking the nearest not polluted place to you. Moreover, through the App, you will have the possibility to search about how polluted are any area you want to check and which green areas are ranked by other users near to you in the city.

For now, I would like to ask to you to answer some short questions and finally I will provide you my phone with a similar existing application and I will let you discover it, interact with it and let you give me any suggestion or opinion you want about it.

So, let's start!

1. Which is the main sport that you practice usually? Is it always outdoors?
2. For how long have you been practicing this sport until today?
3. How often do you practice your sport?
4. Which is the best time for you during the day to practice your sport? Why?
5. Do you follow any specific plan for scheduling your activities? Which?
6. Do you feel affected by the weather sometimes to cannot practice your sport?
7. Before going out from home, do you check the weather in your area?
8. There is any other environmental factor that you check apart from the weather? Which? Why?
9. Which other factors can influence in not practicing your sport usually?

10. Could you explain your experience of the last time cancelling practicing your sport due any environmental factor? How did you feel?

For now, we are done with the first questions. Now, I will bring you my phone and let you discover the next app and interact with it a few minutes. Afterwards, I will ask you some questions about it.

	PLUME APP - INTERACTION
SAY	**THINK**
DO	**FEEL**

11. After looking into the app, what is your first impression?

12. Which information did you find more useful provided by the app? Do you think that the information provided by the app can be useful for you to schedule your sport routines?

13. Which are the features that you like the most about the app? And which less?

14. Finally, do you have any suggestions or any features that you like to be added in the app?

Finally, we are done and that's everything, thank you so much for your answers.

Figure 11: Interview template for outdoor sports practitioners

8.1.5.1. ENVIRONMENT OBSERVATIONS

According to the answers obtained from the 16 interviews done, there are different environment observations considered:

- All the users feel influenced by the weather to be able to exercise outdoors.
- The majority of the users plan their sport schedules according to the weather.
- All the users usually check the weather before going through their sport routines to be aware of any changes in the environment.
- Apart from the weather, the main environmental factors that the users check are the wind, fog and humidity.
- Some factors that some users check due human health are the level of presence of pollen and the air quality index for people with some respiratory diseases as asthma or bronchitis.
- Not all the users consider air quality as a factor to check before doing some sports.
- Professional runners consider air quality as an important environmental factor and check the air quality index time to time to be aware.
- The users feel more aware about air contamination since the government applied new laws about car emissions.
- The majority of the users feel comfortable to use a mobile app to check the weather and other environmental factors.
- The users suggest to implement more features in the app to have more access as being able to register their sport schedules or register with their preferences and the app provide them a schedule alternative.
- The users feel very attracted by the feature of checking the air quality index in a map.
- A lot of users would like to have reviews about the places and opinions from previous users who went to some places.
- Some users feel not sure about some sources of information, they would like to have a solid base before. So, they would like to have like a newsletter or forum in the app with information about air contamination, or how air quality can affect human's health to be updated.

It can be observed that according to the interviewed persons the app can be a good solution for them if includes different features and more than one environmental factor

and allergies to check. So as much complete it is, it will be more efficient for the users and will use it more for multiple uses.

8.1.5.2. RELEVANT TOOLS FOR OUTDOOR SPORT PRACTITIONERS

After having the interviews, the users explained which tools they are used to use to check the weather, or any other environmental factor even some of them also check the air quality. These tools differ from a user to another depending on which information they want to check, however in general terms we can consider the following tools:

- *TV / Radio:* this source is used to know the weather and general environmental factors around.
- *Google:* this source is used to know the weather or any other environmental factor as the wind or humidity in a precise way. For example, to know in which period of the day or which time will start raining.
- *Air Visual / Air Matters / Plume:* those different apps are used to check different data depending on the user as the weather, the pollen level or the air quality index.
- *City Council Website:* is used to check environmental alerts as severe winds and the index of air quality as well.

As it can be seen, all the data checked by the users can be implemented in one application. However, depending on the user may can have different preferences of the source used to check their information, but all of them show interest in having a unique source that can include all the maximum and necessary data possible but being simple and easy to use.

8.1.5.3. KEY NEEDS

After interviewing different people, it was obtained that according to their circumstances they have different needs one from another. It depends in multiple things, as which sport they do, if they practice more than one sport or not, if they are professional sport practitioners or not, if they have any health problem or not… So, according to this couple of differences they were identified the main needs as follows:

- The main need of all the users is to be informed about all the different environmental factors that can cause any change in their schedules or affect them in their health: rain, fog, humidity, wind, pollen, air quality…
- Different sports → Different needs
    - The fact of practicing cycling makes the users in need to check the traffic, the wind and the fog apart from other environmental factors.
- Different health status → Different needs
    - People with allergy to pollen check the level of pollen present.
    - People diagnosed with asthma and other respiratory diseases check the air quality index.
- Different region → Different needs
    - People living in the Vallès Occidental wants to be more aware about the wind as the historical severe winds' alerts.
    - People living in the big cities wants to be more aware about the traffic and the air pollution.

All these different needs can be described as a feature of filtering available in the app, so depending on their circumstances the app should be able to notify the user about the data they are interested in.

8.1.5.4. POINTS OF FRUSTRATION OR PAINS AND GAINS

Following user soul searching exercise or what is called the phase to empathise with the user to get to know what their needs are and what they are expecting from our solution it's time to describe the pains and gains.

The user pains or points of frustration are the negative emotions, undesired situations and risks that the user could experience before, during or after using the app. While user gains are the benefits the user expects, desires or would be surprised by. This includes functional utility, social gains, positive emotions or the efficiency of the solution, so gains are the things that make a user happy, satisfied, or positive about the process.

(-) PAINS

- The hard part of doing the interviews is finding a free time for the interviewed person to be able to have the interview and answer the questions.

- It was frustrating that due the time constraints, I was not able to talk face a face to all the interviewed person and some of them were by skype and made them download the app to check it.
- It was difficult to understand the needs of each user, according to their circumstances they were different needs and suggestions.
- For the user is frustrated to not be able to check easily and quickly the level of pollen present.
- For some users is difficult to find an app that includes all the information they want to check. The fact to have to download more than one app to be able to have the control hinders the process.
- Users would like to have one source that they can use for checking environmental factors and write down their sports schedules and control and register their routines in.
- Some users were not aware about how air pollution can affect their health and even do not know that there are existing apps that let them check this environmental factor.
- Some users find difficulties in understanding which use they can give to the app.

(+) GAINS

- All the users were interested in the interview and happy to talk about their sports.
- A lot of users feel attracted by the app and would like to give it a try.
- All the users know which are their needs according their sports and what would they like to be implemented in the app.
- The users interact easily and quickly with the app.
- The users feel involved in the process of scheduling their routines and wanted to be more aware about different environmental factors.
- Users gave a lot of suggestions related to the app which ensure their use if those suggestions are implemented in the solution.

8.1.5.5. EMPATHY MAP

An empathy map allows us to sum up our learning from the interviews in the process of design thinking. The map provides four major areas in which to focus our attention on, thus providing an overview of the person's experience which in this case is the interaction with the Plume app in the second phase of the interview. The four quadrants reflect four

key traits, which the user demonstrated during the interviews. Those four quadrants refer to what the user said, did, thought and felt. For the first two is easy to determine, however the last two are based on observations and analysis of how they behaved and responded to certain activities. The user's empathy map created after the 16 interviews done is presented next:

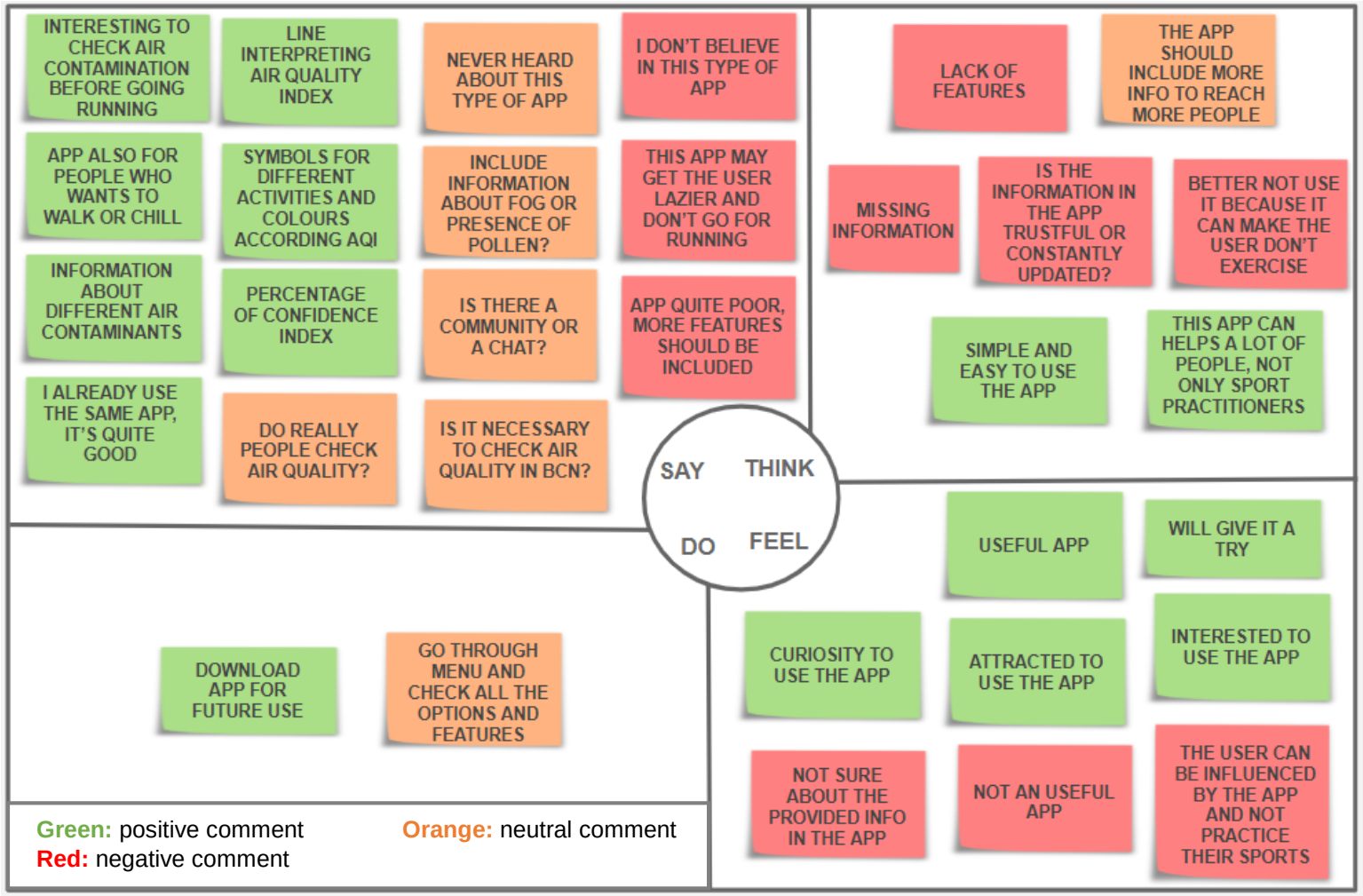


Figure 12: Empathy Map

8.1.5.6. CLUSTERING

The next step is to cluster in themes and patterns the information obtained in the empathy map to be able to analyze this information to know the users' needs and suggestions. In the next figure we can see the different themes and patterns (pains and gains) that were translated as a insight statement or opportunity in the post-it in blue:

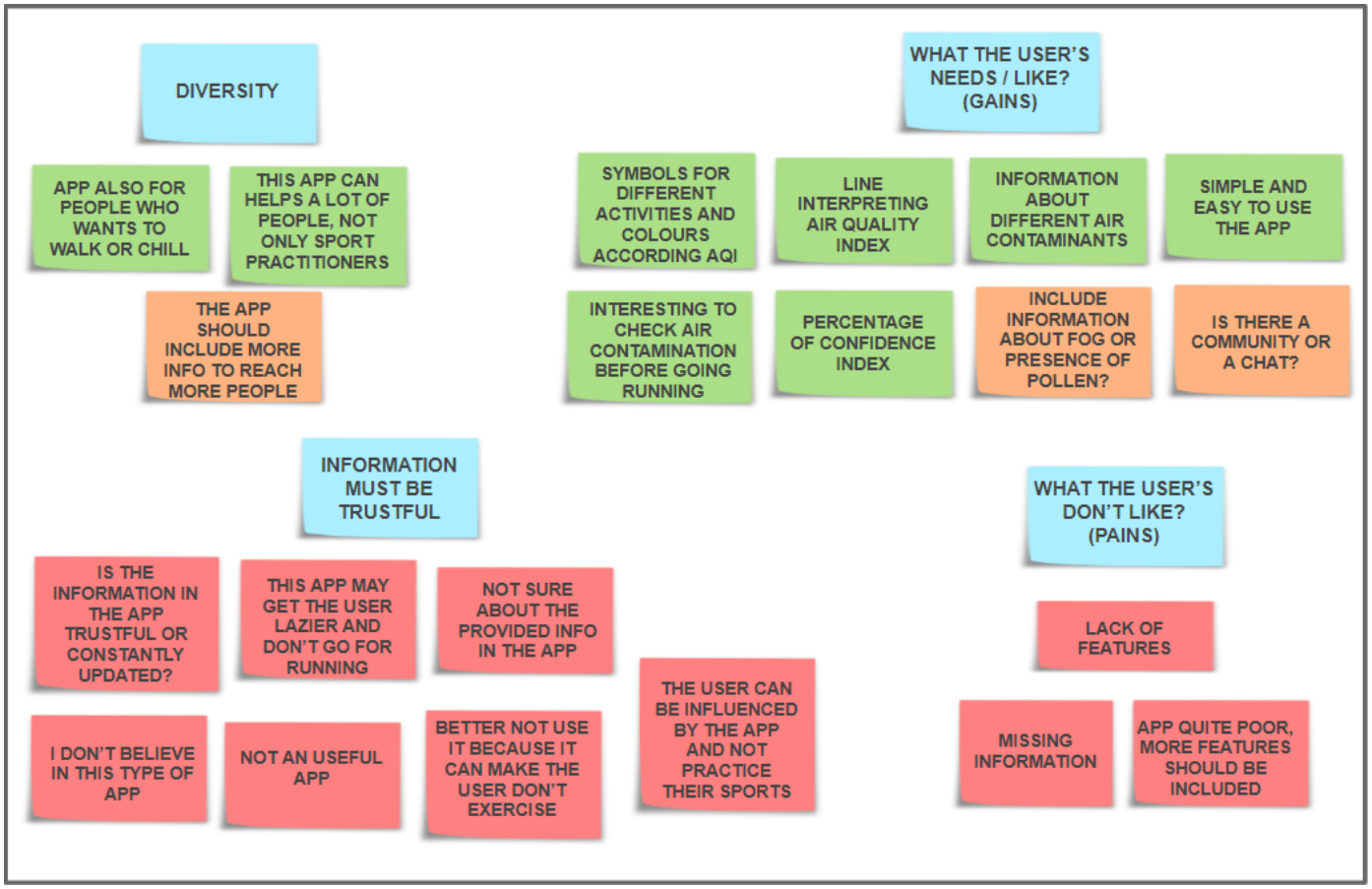


Figure 13: Clustering

8.1.5.7. VALUE PROPOSITION CANVAS

The Value Proposition Canvas (VPC) is a tool which can help ensure that a product or service is positioned around what the customer values and needs.

The Value Proposition Canvas was initially developed as a framework to ensure that there is a fit between the product and the market considering the relationship between the customer segments and the value propositions.
The VPC is formed around two blocks that represent both customer profile and the company value proposition. The first one is formed by gains, pains and jobs whereas the value map considers gain creators, pain relievers and products and services. These concepts are described below to be able to understand the classification made in the map after the clustering process.

- **Customer Profile:**
  - **Gains:** the benefits which the customer expects and needs, what would delight customers and the things which may increase likelihood of adopting a value proposition.
  - **Pains:** the negative experiences, emotions and risks that the customer experiences in the process of getting the job done.
  - **Customer jobs:** the functional, social and emotional tasks customers are trying to perform, problems they are trying to solve and needs they wish to satisfy.
- **Value Proposition Map:**
  - **Gain creators:** how the product or service creates customer gains and how it offers added value to the customer.
  - **Pain relievers:** a description of exactly how the product or service alleviates customer pains.
  - **Products and services** the products and services which create gain and relieve pain, and which underpin the creation of value for the customer.

After listing gain creators, pain relievers and products and services, those can be presented in prioritized way, which means that each point identified can be ranked from nice to have to essential in terms of value to the customer and this will be seen in the map created below.
Finally, to achieve a fit overview between the customer profile and the company value propositions the products and services offered in the second one must address the most

significant pains and gains from the customer profile.

In this first part, only the customer segment has been studied with the value proposition map while the gain creators, pain relievers and product and services are going to be developed in the next chapter.

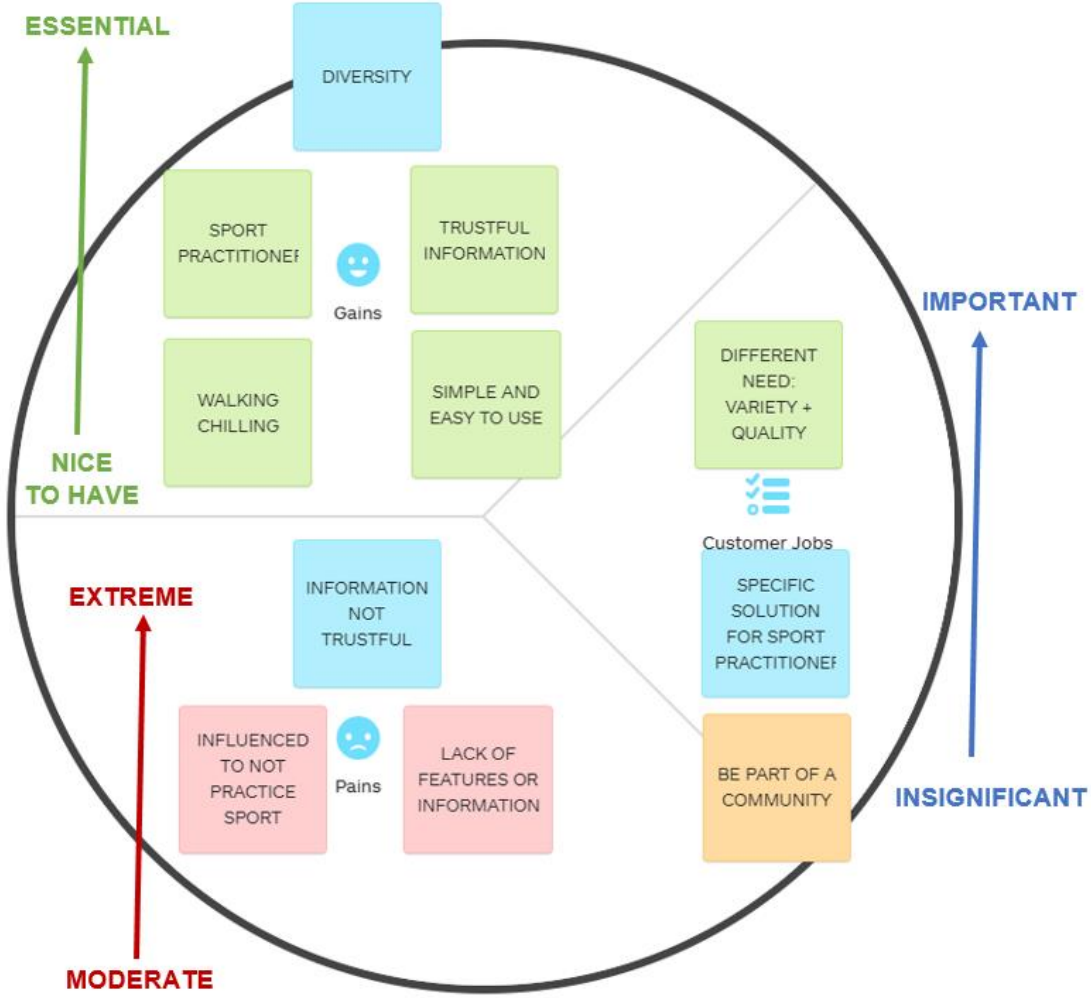


Figure 14: Customer Profile Segment of the Value Proposition Canvas

8.2 2st PHASE: DEFINE

The second phase of the Design Thinking is to Define, so first we must understand and describe what is it about the "*Process of Definition*".

This phase considers to state the users' needs and problems after the development of the empathy stage. In this phase it's important to analyse and synthesize the information obtained in the previous phase and be able to develop an own insight to define the core problems identified. The problems may be defined as a problem statement in a human-centred manner. The result obtained from this definition is a brief description of the main proposed solution that will solve those detected problems.

8.2.1 PROBLEM STATEMENT

Nowadays, air pollution has been converted in a big problem related not only to environmental factors in the earth but even in human's health. Vulnerable groups as elder, pregnant women, children, people with respiratory or cardiovascular diseases as asthma, bronchitis or others, people with allergies as to pollen or even professional or outdoor sport practitioners are the ones who find it more difficult to face this problem and develop certain activities safely as going out to sit somewhere, go walking or do exercises like running or cycling.

So, how can I know if the air quality index of my city is bad or not? When is the best time of the day to go out in my neighbourhood? Can I schedule my routines some days before? Is it possible to know the weather conditions? Can I check the presence of pollen? Can I get more information about air pollution in my city? How can I help to reduce the air contamination impact?

8.2.2 DESCRIPTION OF THE PROPOSED SOLUTION

- **Name:** AirFree
- **Aim:** AirFree aim is to provide a useful and fundamental service for all the people who is suffering in a healthy way directly or indirectly from the air contamination. In particular, we want that any user is aware of all the factors that can affect him according to his health situation and take the correct preventions. For example, a person suffering from pollen allergy be able to check the pollen

presence in his city while a person suffering from bronchitis check the air quality index.

The main idea is to give to the user two options:

1. The first one is to provide to the user the option to check the environmental conditions of any area he wants nearby by introducing their addresses.

2. The second one is to provide to the user a weekly report to be able to schedule their sport activities for example according to the environmental conditions. In this case the customer after creating his profile has to fulfil their interest, as which are the mains features they are interested to check in the app, which sport they practice, in which urban area and which timetable they prefer.

8.2.2.1. AD-LIB

- **Our** application, visual marks, online platform and intelligent feedback platform provider driven services are meant to
- **Helps** people who are sport practitioners or people with allergies related to air contamination or any illness that can be affected by the air contamination
- **Who want to go** outside and practicing their activities as sport, walking or even chill in a safe way
- **By Ensuring** they do not have to go back home due any bad environmental factors as they receive trustful information
- **And enjoy** customised programs and schedules,
- **unlike** the not specific other strategies already in the market.

8.3 3rd PHASE: IDEATE

The third phase of the Design Thinking is to Ideate, so first we must understand and describe what is it about the "*Process of Ideation*".

Once the profile of our clients has been defined and their problems and needs identified, the time has come to start devising solutions or develop ideas to solve those problems.

The ideation phase of the design thinking process focuses on understanding and synthesizing all the discoveries from the previous phases: empathy and definition. From these discoveries, new ideas will be sought to solve user problems.

By identifying the real problem, the "Ideating" stage not only allows us to create a solution, but through innovation leads us to find the best one: a solution that will be discovered in the next stages, when it is carried out and be tested by users.

The main objective of this process is to obtain the maximum ideas possible without discarding any and work on them in the next phases until they are prototyped and tested to be validated.

In particular, for our experiment we find different solutions. From simple actions to add notification option, from integration by giving the user some tips to reduce in air contamination or even more complex actions, which entail a strategy such as: develop a system that can provide you a schedule activities according your profile.

8.3.1 METHODOLOGY

One of the most important methodologies to start with in the ideation phase is the brainstorming. The brainstorming technique is, par excellence, the one most used to generate a large number of ideas in a short time and is the one that we will use. One of the keys to achieving a good brainstorming is not to be afraid to contribute absurd or wild ideas, since the objective is to get many without judging. However, the creative challenge must always be in mind and try not to get off from the topic.

The methodology used was going through each pain, gain or job obtained in the Customer Profile Segment from the Value Proposition Canvas, and ideate some solutions for each. The ideas were drawn down in different papers as simple as possible to be understandable and numbered to make it easy to follow how many ideas were generated. These it can be seen in the next chapters.

8.3.2 IDEATION PROCESS

8.3.2.1. IDEATE PAIN RELIEVERS

This chapter we will procedure in the development of the pains identified in the empathy phase in the customer profile in the value proposition canvas. This development consists in analyse each pain and ideate different possible solutions that can be applied in the application to fulfil this user need. The pains obtained previously are the following:

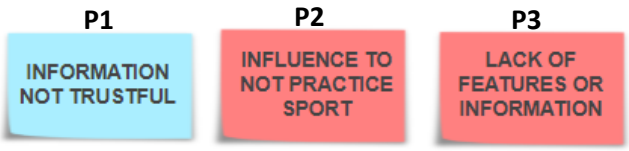


Figure 15: Pains from Customer Profile Segment

- **Information not trustful** → Reliability

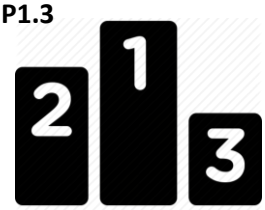
P1.1

Certification or validation from the city council for trustful data.

P1.2

Comments or reviews from other users.

P1.3



Rankings by the users for the places suggested by Air Free.

- **Influence to not practice sport** → Usefulness / Motivation

P2.1

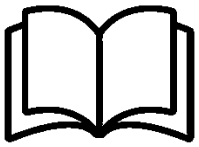
Notifications when it's the best time of the day for exercising

P2.2

Weekly schedule of activities according previsions

- **Lack of features or information** → Keep updated

P3.1



Weekly recommendations and monthly newsletter with updated info

IDEATE

8.3.2.2. IDEATE GAIN CREATORS

In this chapter the gains obtained in the customer profile segment from the value proposition canvas has been developed to ideate gain creators to fulfil the users need identified. The gains obtained are the following:

Figure 16: Gains from Customer Profile Segment

- **Diversity**

G1.1

Create diversity of sections for different kind of users that can be affected by poor air quality: runners, cycling practitioners, childs, elder, pregnant women, people with allergies or even people who would like to chill.

- **Sport practitioners**

G2.1

Profile registration to know the user and give facilities

G2.2

Schedule of routines

- **Walking/Chilling**

G3.1

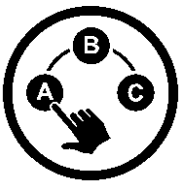
Suggest places nearby with good air quality

G3.2

Count Steps

- **Simple and easy to use**

G4.1



Different symbols and icons with drawings

IDEATE

8.3.2.3. IDEATE PRODUCTS & SERVICES

In this chapter it has been ideated the jobs described before converting them into services. The jobs obtained before are the following:

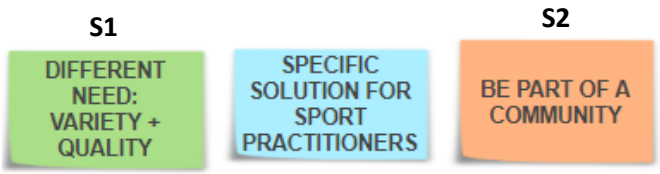
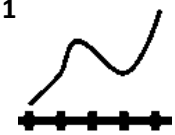


Figure 17: Jobs from Customer Profile Segment

- **Different needs: variety + quality** → Diversity in features

S1.1 
Graph of air quality

S1.2 
Weather conditions

S1.3 
Presence of fog

S1.4 
Presence of pollen

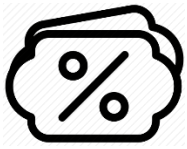
S1.5 
Limits of air quality according activities

S1.6 
Air pollution composition

S1.7 
Downloadable report with chosen info

- **Community**

S2.1 
Forum for suggestions

S2.2 
Coupons with discounts in some gyms

IDEATE

8.4 4th PHASE: PROTOTYPE

The fourth phase of the Design Thinking is to Prototype, so first we must understand and describe what is it about the "*Process of Prototyping*".

The purpose of this phase is to convert the idea or solution we have arrived it in the previous chapter at into a digital or physical prototype. This prototype is usually one of the final elements with which the user can interact and is used for testing.

It should not necessarily be an object, but also a drawing or even a storyboard. In the case of Design Thinking, the prototype can be made with inexpensive materials and tools as paper or cardboard. The great advantage of using this approach is that you can gradually make improvements to the prototype without spending too much.

As in our case we are developing and app, before realizing the ideas it has been drawn the screens with which users interacts. This allows us to create a design tailored to the user's needs and putting the design on paper let us to know if it is attractive, intuitive and, of course, if it follows the usability criteria.

8.4.1 IDEAS PROTOTYPED

- **Welcome in AirFree** → One of the problems to face is to make the user feel that the information provided by AirFree is totally trustful, for that reason it in the first page when you open the App you can find a logo provided by the City Council that justify that the data is totally official and is provided from them (P1.1).

Figure 18: AirFree first screen

- **AirFree presentation →** Welcome screens to get to know some features of the app and show them how simple and easy is to use (G4.1).For the first one is to let the user now that he will be able to check air quality anywhere, while the second to let him know about being able to plan and schedule activities whereas the last one is to let him know that he can follow his exposition to pollution during all day.

Figure 19: AirFree Welcome Screens

- **First settings →** The first settings are to activate the location and the next one to activate the notifications where it's shown to the user the different possibilities the app has, from notifications (P2.1) about when there is poor air quality, pollen pollution, the best hour to go out or even a weekly report about your exposition to air.

Figure 20: AirFree First Settings

PROTOTYPE

- **MyAir →** In the first section, all the different features are presented according to the users location. The user can check the air quality (S1.5), pollen allergy (S1.4), air pollution composition (S1.6), weather conditions (S1.2), fog presence (S1.3), graph of air quality data history (S1.1) and also the air quality forecast where the user can download a report with the near future prognostics for a chosen period like air quality index or weather conditions (S1.7).

Figure 21: AirFree MyAir Section

- **MyPlanet →** In the second section, the user can check a map where he can choose which information want to be shown, from air quality index, presence of pollen, CO2 or others and choose the best place nearby (G3.1). Furthermore, it can be seen the rankings (P1.3) and comments or reviews from other users (P1.2) to some places and be able to go there to do any certain activity.

Figure 22: AirFree MyPlanet Section

PROTOTYPE

- **MyProfile** → In this section, all the data related to the user is presented. The user can check the number of steps (G3.2) he has done, the exposition to pollution he has, identify himself to which group he belongs (G1.1) like sport practitioners, pregnant or has any disease between others. Moreover, he can adjust the level of sensitivity to pollution he has, identify his favourite activity (G2.1), plan his schedule and downloaded (P2.2 / G2.2) or even get a report about his exposition to contamination.

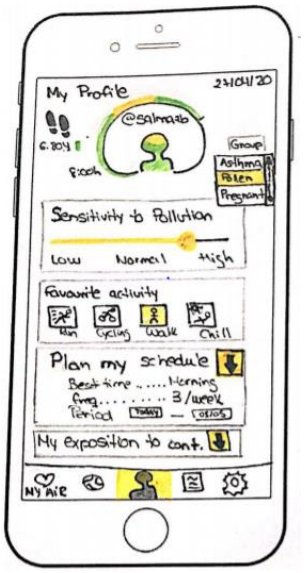


Figure 23: AirFree MyProfile Section

- **Newsletter** → In this section, the user can find articles, recommendations according his profile (P3.1), a forum (S2.1) where he can check other users concerns or suggestions and also an advertisements section (S2.2).

Figure 24: AirFree Newsletter Section

PROTOTYPE

- **Settings** → The last section is the app is the settings where the user can check and adjust some tools.

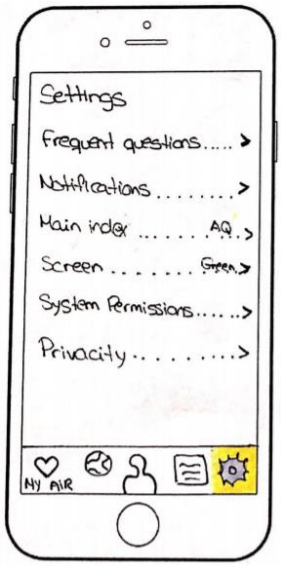


Figure 25: AirFree Settings Section

PROTOTYPE

8.5 5th PHASE: TEST

Finally, the last phase of the Design Thinking is to Test, so first we must understand and describe what is it about the "*Process of Testing*".

In the final phase of testing we will aim to see if the idea that we have thought and developed will finally get the desired feedback from the target audience. We will also learn what prototype things work and had to change. It is about testing the proposal and modifying it so that the final product is as adapted as possible to the chosen objective.

For this case the ideas prototyped in the previous chapter were presented to some users that previously were interviewed in the empathy phase and get to validate the ideas with them and take in consideration their suggestions to make some changes in develop better the ideas.

8.5.1 VALIDATION OF IDEAS

- **Welcome in AirFree** → For this screen a lot of users said is not necessary to add this logo and prefer to create an option in the Settings section to be able to check this kind of information, so there they can read more about the provided data with more details and it will be better than a logo. So, this idea was approved and applied for the future development of the app.

- **AirFree presentation** → A lot of users like the idea as they can get to know what they can find in the app, however a lot of others suggest to add a Skip button to be able to skip the presentation if they want and prefer just go through the app and discover everything while using it. This suggestion was approved as well and the Skip button will be added.

- **First settings** → A lot of users said that it's necessary to do this adjustments at the begging where some comment that maybe some users will don't like to share their location, until they check the app and realize why it's necessary to add the location. So, for that reason a Skip button has to be added and let the user adjust his location if he wants later.

- **MyAir** → For this section all the users find it's quite complete, a lot of them like it the Report Prognostics but where not sure about the veracity about it.

- **MyPlanet** → This section was very attractive for all the users, all of them enjoy the map section and support the ranking option as well.

- **MyProfile** → This was considered the best section of all the app and considered something new to be able to check their exposition to pollution. All users were agreeing that this section was totally complete and find it very personalized with a lot of diversities for all the groups.

- **Newsletter** → This was very supported by the users and they asked for notifications when new articles where posted related to their interests. This has been approved as well and added to the app.

- **Settings** → This last section was normal for all the users, finding no importance on the features or nothing. They just comment to add there an information section about were the data is provided from and that's it.

9. STRATEGY AND VIABILITY ANALYSIS

The first step to realize a viability analysis is to carry out a market study in which the application will be launched. Since the idea is to launch the application at least initially in Spain (later, the possibility of expansion to other territories will be studied), the analysis will be considering Spain as the territory on which to launch the app.

9.1 MARKET ANALYSIS FOR AIR QUALITY MOBILE APPS

In Spain, we can find access to not more than 250 apps dedicated to check air quality, which demonstrates how small is this market if we compare it with for example sport apps that provides you subscription to routines and personalized training programs.

According to the International Data Corporation in Spain, 78% of the adult population in Spain uses mobile applications daily. With more than two million mobile applications available between Apple Store and Google Play, a figure that has doubled in the last two years, the app sector is in constant growth. Consumers spend on average two hours a day on apps what makes this sector one of the most attractive for investors. Apps lead the way for entrepreneurs and new business opportunities.

In the last two years, sport and environmental apps are becoming a sector more competitive, active and dynamic that have been multiplied. The data provided by the sector shows the increase every year in the research for applications related to sport and environment and also the look for information about this last one.

The sector's forecasts prevent that sport and environment applications will continue to appear and new versions of existing applications as well, that can add a line more income to companies in the industry, as well as supplying an improvement in brand recognition.

However, if we focus on air quality index applications is a sector not easy for anyone as sport applications. Those apps need air quality data that has to be provided from professionals' and national data institutions as the case of the Barcelona Supercomputing Centre that measures air quality and other environmental factors. In Spain, the City Councils and the Autonomous Communities are responsible for carrying out the data collection and evaluation of air pollution to protect the citizens.

Another important point that IDC highlight is that both Google Play and App Store environmental apps represent less than the 3% of total downloads, but instead, when referring to revenue generated by applications, environmental apps can represent an important percentage of the generated income.

Finally, the type of user must be taken into account according to the platform used to access the applications, since each user on one platform tends to behave differently from other platforms. In the case of environment apps, at the download level, most are made by Android users, whereas on the other hand, when it comes to purchasing it is Apple users who make the most expenses. Something to point out is that environment apps that provide shopping and subscriptions in, are the ones available in Apple Store while the majority ones in Android don't present this features.

9.2 COMPETITORS

Competitors will be understood as those products that satisfy needs identical or similar to those that the product will cover. So in this case we can compare it with environmental apps, but with air quality index apps which their market is quite limited.

Previously, it has been studied the features of similar apps, however in this case another factors have been considered. So, to carry out a more consistent and personalized market research on air quality apps the following actions have been taken:

- Search both Apple Store and Google Play for similar applications using different key words or texts related to the app proposed.

To start with the competitors' analysis for AirFree, the first thing that has been done is to search in Google Store by the same name of the app and related key words. The vocabulary used in this search are the following: air free, air, air quality, air quality index, air pollution, pollution, ICA and AQI.

In the case of using the same name nothing appears, while when we use air a lot of applications appear related to different topics as games or planes applications. The key words used where they appear more than 200 apps related is when using air quality and air pollution, however, not all of them have the same functionality.

- Perform another search by categories to see if the previous search has ruled out any interesting app that should be taken into account.

The same apps were found in the weather category, no one of them in the sport category, so the main aim of them is to check weather and environmental factors.

- Check the number of downloads of applications of the same style and if they are free or paid.

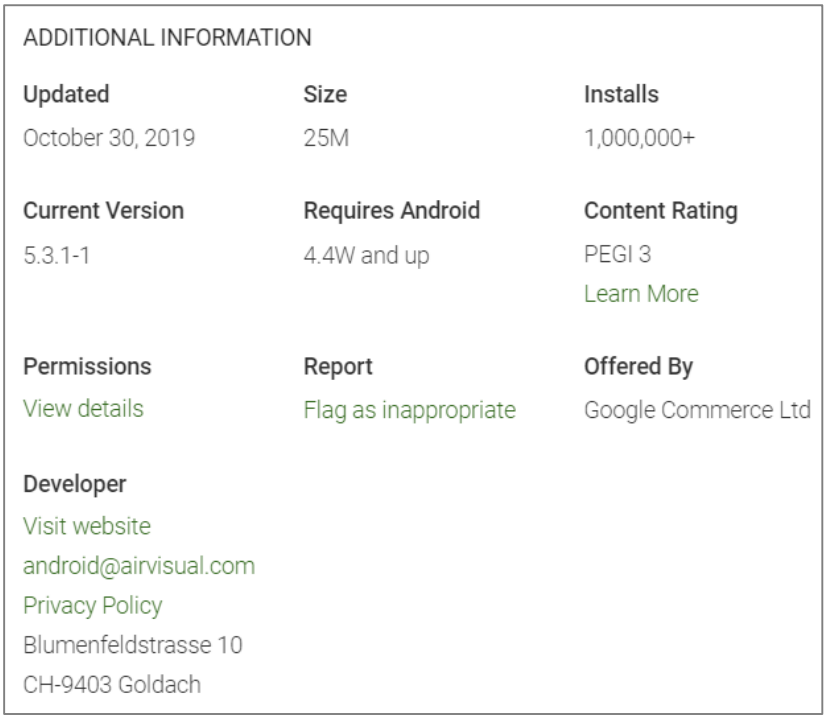


Figure 26: Air Visual data in Google Play

The application checked is Air Visual, as it is the most similar one to AirFree, furthermore is the first one that appears in Google Play.

It can be seen that the app has more than 1.000.000 downloads and it's totally free without any subscriptions or shopping inside the app. The amount of downloads demonstrates without any doubt that creating a similar style app can lead to quite significant results. If you analyse the advertising it is clear that Air Visual has been success for the developer.

However, it must be borne in mind that in order to obtain such a number of downloads, a budget must be invested, which may be considerable, in the resources to develop the app, in its advertising or in the commission paid for the Google Play account. All this different costs can make the final benefit not as important as originally expected.

- Observe the evaluations and comments that users make about these apps, in order to detect what the users are looking for and what they are interested in and not in the app.

The next point that must be analysed and that will help to better understand the reason for the number of downloads, is how users value the app. In this case, the majority of evaluations are 5 points, which is the maximum evaluation mark, as shown in the following figure:

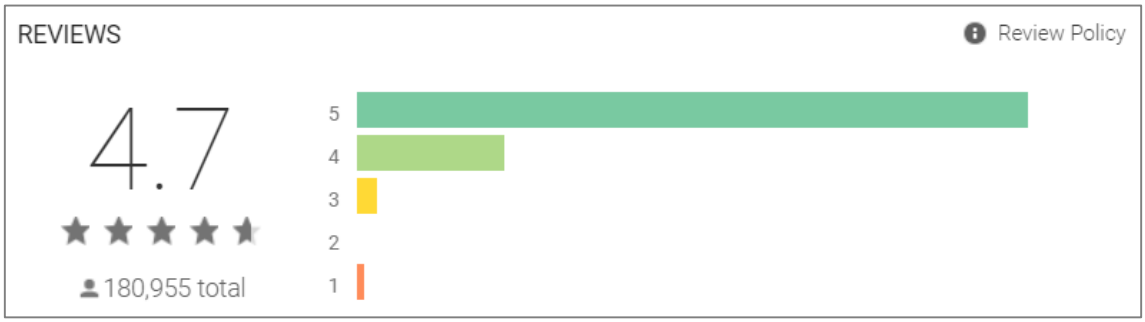


Figure 27: Air Visual Review in Google Play

Another point to analyse is the opinions that users express about the app. These are a very important tool to develop future air quality apps since they allow knowing what is the features that the users like the most, what they like least, what they miss or any other vital information. This information will allow the developer to have their app with the most attractive features for users and in this way, achieve success more easily. For example, below is a positive comment to consider, in which a user highlights that the app is good for human's health and useful for people with chronic illnesses or even the ones who would like to exercise.

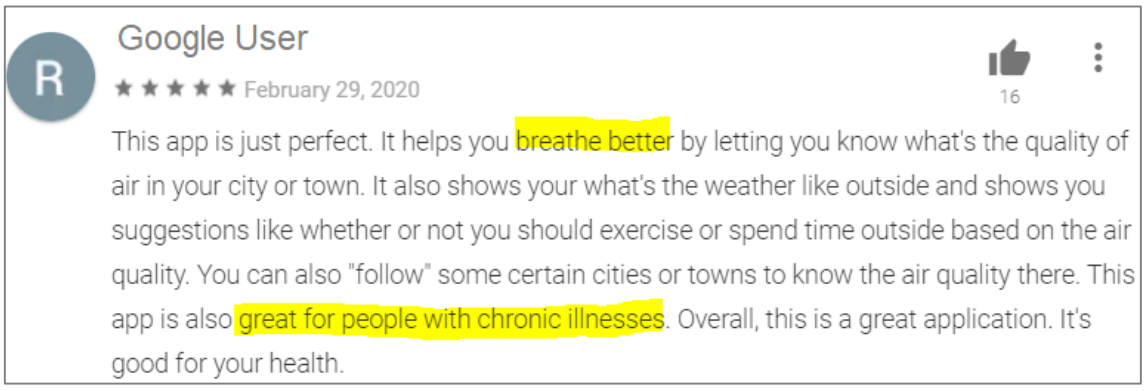


Figure 28: Air VIsual User Comment in Google Play

9.3 POSITIONING

The main mission of AirFree is "*Breath better anywhere*" and that is related to the sense of freedom that humans like to feel and made them feel empowered.

As human's beings, we always want to be part of something and at the same tame feel free, although we have taken it for granted all the times.

In this era where new technologies break borders and the factor of high consciousness that people have about air pollution and how is affecting the planet and our health made the application a very attractive to them.

The meaning of AirFree is to breath an air totally free of contaminants and pollution and as well the concept is to feel free to breath anywhere as you will be able to control the air you are breathing.

Figure 29: AirFree App Logo

Furthermore, once you are in the app the sections are named by the "My" possessive pronoun as MyAir, MyPlanet or My Profile. This strategy is to made the user feel that the app is belonging to them and work in the universal human needs of feel free and belonging as well.

So, in relation to other similar services, as in this case the apps we have analysed and compared features previously, we can have the following positioning map:

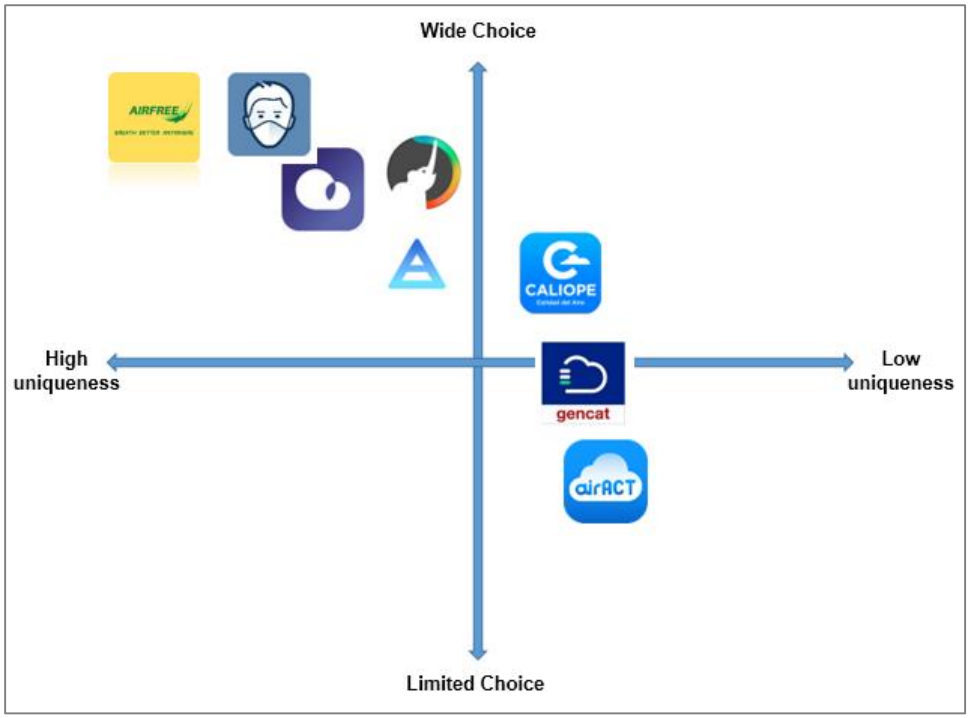


Figure 30: Positioning Map of Air Quality Apps

In this positioning map, it has been considered the fact of the high uniqueness that AirFree have by being the unique air quality app that has a section that follows up your exposition to contamination, which make it a very outstanding for innovators and especially experiencers that follow the last trends. At the same time, the fact of the positioning in relation to the margin of choice makes it more attractive for different kind of users as there is a wide choice of features which will encourage innovators that usually consider this factor in relation to their consumptions as having a varied target segmentation.

9.4 TARGET

When you want to launch a new product on the market, one of the most important points is to define the target audience. Target audience means all those people who show interests and/or need to acquire a specific product, in this case the app of AirFree.

The need to analyse and detect the target audience makes it possible to concentrate both the effort and the resources made on strategies or advertising, directly on this set of potential consumers.

The targeting strategy of a company consists in grouping the customers in different segments in order to identify the need of each of them and try to please them in the best and most profitable way.

- **Segmentation of users:** as it has been studied and said before, for this app there is a quite diversity of persons that can have the need of using AirFree, however, we can consider the main following groups:
    - **Outdoor sport practitioners**
        - *Gender:* in Spain 62% of sport practitioners are considered men. However, the app cannot be addressed to them until checking the real gender of the users after one year of usage for example.
        - *Age*: it's expected that this segment will be people between the 28 and 45 years old, as this age is considered in which people care the most about their health.
    - **People with healthy problems** that affect their respiratory system as: respiratory diseases (asthma, bronchitis…), cardiovascular diseases or cancer between others….

- *Gender:* in Spain, the 68% of people who suffer from respiratory and cardiovascular are women.
- *Age*: for this case we might think it's for more old people, however there is a significant number of people who suffers from asthma in Spain, so for that reason it's starts from 32 to 74 years old.
  However, we don't expect that people of more than 65 years use the app due the usual lack of knowledge of technology in this ages.

- **Pregnant women**
  - *Age*: between 28 and 42 years old

- **Parents that want safety breathing for their children**
  - *Gender:* in this case is difficult to analyse as both mothers and parents feel in charge about the health of their children.
  - *Age*: for this case usually the expected users are new parents that their ages are between 28 and 45 years old as well.

9.5 SWOT ANALYSIS

The SWOT analysis was developed to expand on the strengths, weaknesses, opportunities and threats affecting the company's future success. In the diagram below, the main features have been presented:

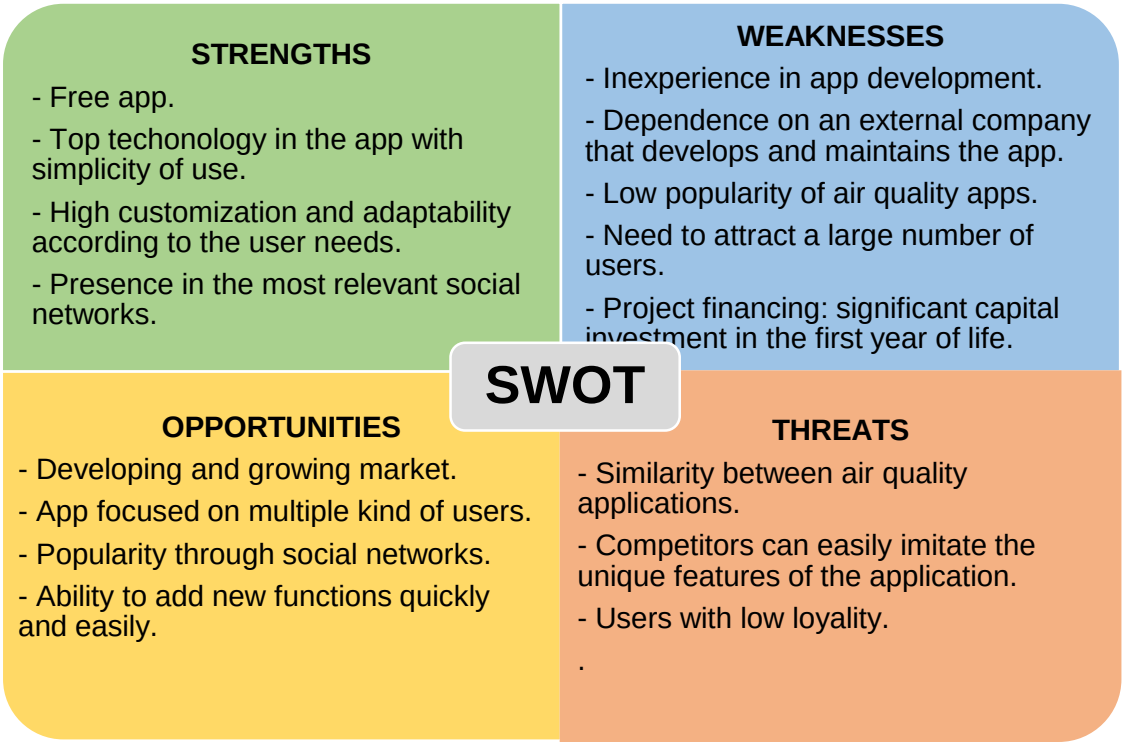


Figure 31: SWOT Analysis of AirFree

In relation to the strengths is not only about being free or the high technology that the app can provide, but it's more about the trustworth and customization that the brand can give to their users. AirFree, it makes the user feel in the first positioning and empowered to have his exposition to contamination controlled.

In case of the opportunities, AirFree does not only make any kind of user confident as having a personalized follow up, but it also made their users feel more secure by sharing, ranking and even have forums where to debate and share with other users.

Finally, in relation to the weaknesses and threats it is really clear the difficulties to face when it's about a commercialisation of a new app and it's financing.

Once the SWOT analysis has been carried out, what must be done is to specify certain measures to minimize the impact of weak points and maximize the benefits that strong points bring us. The measures to be applied in the future for each section of the SWOT matrix are shown below:

- **Strengths:**
  - Try to maintain the strengths that users demand, both to maintain current ones, as well as to penetrate more into the market and obtain new users.
  - Know the desire and need of users to extend their loyalty throughout the life of the game.
- **Opportunities:**
  - Know the different trends that are occurring in the market in order to adapt the product to what users request and not lose market share.
  - The differentiation of the app within the market must be maintained, be aware of any app that may have certain similarities and make updates to continue differentiating the solution from the rest, thus maintaining the attraction of users.
- **Weaknesses:**
  - Knowledge and experience in developing mobile applications should be improved, both to make improvements to existing features and to develop future implementations. A continuous development of skills and knowledge will always be an added value.
  - Try to know the best and most optimal models of promotion and marketing to publicize the app. The popularity of the app is usually one of the most important characteristics to obtain future income, as well as increase the possibilities of external financing if necessary.

- **Threats:**
  - Always stay at the forefront of technology to not become obsolete, since the competition is very large and a single step back could mean the loss of enough users. The solution must always be kept up to date and attentive to the demands of the users.
  - Always take into account the possibility of similar competition and try to differentiate ourselves from them as much as possible.

9.6 LAUNCHING STRATEGY

Once the application is in the final stage of the development process and performing the last tests and checks to launch it officially, the communication and advertising process it will be underway, so that the potential users know the application before it goes on the market.

To choose a good day for the official launch of AirFree it is a gran issue and more important as we can expect. It is recommended to avoid holidays, weekends or important holidays such Christmas or the month of August since the use of the smartphone is more intensive in work periods.

According to several studies that have been carried out on the Google Play and App Store platforms, the best day to bring out an application is Thursday, since Thursday is the day with less activity on these platforms by developers and that can influence that the app can stay high on the list of what's new all the way to week, thus increasing the chances of being viewed and downloaded.

As for the most appropriate month to bring AirFree to the market, there are two possibilities, March or September, the first one considering the arrival of the spring and the usual increase of allergies or the second one according to the period where people decide after a long holiday to go back training and exercising after some pauses.

Once the ideal launch date is chosen (exact day), the advertising for the days before and after will increase. The first days of existence of the application must be achieved a good number of downloads, because if this does not algorithms that rule app stores will scroll it down in search listings and results.

10. ECONOMIC ANALYSIS

The costs of launching this business idea, creating AirFree and starting to market of applications, include some initial costs, which are those related with the creation, commissioning and first year of life of AirFree and later the costs once the application is already working on the market. For creating a budget as much as complete as possible, different costs has taken in consideration and have been studied gradually in the following chapter.

10.1 BUDGET

The budget for the commercialization of AirFree are composed by the next multiple factors that are studied in the next pages:

- App creation costs.
- Application maintenance costs.
- Registration costs as developers at Apple and Google platforms.
- Company creation cost.
- Trademark and trade name registration cost.
- Personal staff costs.
- Technology equipment costs.
- Office costs.
- Communication and marketing costs.

10.1.1 APP CREATION COSTS

The main initial cost that AirFree will have is that of creating the application itself. To create the solution, it will be contracted the services of an external company specialized in the design and creation of mobile applications. Considering, that AirFree is a complex application, which requires multiple functions and features which increases the cost of creation necessarily, thus the data provided from the city council. The minimum requirements to be asked of the company to be hired are the following:

- The app must be developed for Android and iOS operating systems.
- The app must be developed for both Smartphone and Tablet.
- The design of the app will be personalized following the specific patterns.

- The application will be required to allow users to register through a username and password or through their Google or Facebook account.
- Use information and generate information in connection with databases data provided from the city council or national institutions.
- It will require large servers that allow a large number of connected users interact at the same time.
- Features of a social network for the forum section and for ratings and reviews.
- Geolocation.
- Notifications.
- Data encryption.
- It must be available in two languages as minimum, Spanish as a first option, but also English, so that it can be used by tourists or students from exchange programs.

Following all these characteristics and requirements, a budget has been requested via online to different platforms specialized in mobile applications.

All quotes obtained were provisional and without VAT, since the price or the exactly final cost will be obtained once the order is made and the all the needs, problems and changes are identified during creation.

Considering this, and the budgets that have been received that vary from 15.000€ to 23.000€ it has been decided to estimate the cost of creating AirFree in five months at 25.000€, which will be 30.250€ if the VAT is added.

10.1.1 APPLICATION MAINTENANCE COSTS

The costs of maintenance will be contracted as well from the same company that will develop the app, considering the budget received it will be approximately 400€ per month with VAT included.

10.1.2 COMPANY CREATION COSTS

In the case of creating a company in Spain, is it necessary to face the costs of negative name certification which are 20€, the public deed of incorporation of 500€ and inscription in the Mercantile Registry which costs 300€. The total obtained for this is 820€ considering that the VAT is included.

10.1.3 REGISTRATIONS COSTS AT APPLE AND GOOGLE

In the case of creating an app, it is necessary to pay an annual registration in both platforms, for Google is of 25€ whereas for Apple 99€.

10.1.4 TRADEMARK AND TRADE NAME REGISTRATION COSTS

As any country, when creating a new brand, it is necessary to pay fees to register the brand, logo and commercial name. AirFree is going to register as a brand in international level, through The World Intellectual Property Organization, since this way if in the future you want to expand the business to other territories you could use the same brand and trade name without problems. The costs to pay for its registration is around 780€ considering the VAT.

10.1.5 PERSONAL STAFF COSTS

To get the app developed and running, it will be needed a staff capable of managing all the tasks that derive from the implementation of the solution. For this study it will be calculated the cost of the personnel that is considered minimal to be able to operate, but later and according to AirFree growth market, it would be necessary to hire more employees. In the first term we count with the followings:

- *Project Manager*
- *Community Manager*: in charge of social networks and communication by internet in addition to customer service
- *Computer Technician:* expert in mobile application, in charge of technical incidents that may arise.

Additionally, part-time students (scholarship holder) may be contracted to support some of the tasks of these essential personnel.

The total cost of the personal staff is in the following table:

Job	Nº	Monthly Cost
Project Manager	1	3.500€
Community Manager	1	2.500€
Computer Technician	1	2.500€
		8.500€

Table 7: Personal Staff Costs

In this case, the total cost includes the worker social contribution that is paid by the company.

10.1.6 TECHNOLOGY EQUIPMENT COSTS

In order to start working on the development of the app, it will be necessary to provide to the staff minimum one computer per employee, and it will also be necessary to test the application, updates, changes and tests in Android and iOS devices so for that reason mobile and tablets devices will be acquired. The cost of these devices are described in the table below:

Device	Nº	Cost
Developed Computer - Dell Inspiron i7559 (Intel Core i7 processor, 8gb of RAM, 1TB of HHD memory and 8GB SSD plus and NVIDIA graphics card)	2	1.600€ (800€/u)
Office Computer - Dell Latitude E5450	2	700€ (350€/u)
Mobile devices - Samsung Galaxy A51 - iPhone 8 Plus - Xiaomi Mi Mix 3 - iPhone 11 - Motorola G5	3	2.150€
Tablet devices - IPad Mini 2 32GB - Huawei Media Pad T5	2	450€
		4.900€

Table 8: Technology Equipment Costs

10.1.7 OFFICE COSTS

To develop this business, is it necessary to rent a furnished office in the city of Barcelona that costs around 1.200€ per month, so, a deposit of 2.400€ will have to be paid at the first month. Furthermore, the following expenses have to been considered:

Concept	Monthly Cost
Office rent	1200€ + (2400€)
Electricity	70€
Water	35€
ADSL + Telephone	90€
Assurance	25€
	3.820€

Table 9: Office Costs

The supplies of water and electricity vary depending on the month and the expense made, thus it has to be considered that water is paid every two months. In relation to the assurance it corresponds to a fee of 300€ per year.

10.1.8 COMMUNICATION AND MARKETING COSTS

The costs derived from communication and advertising will be those that impact the ads on social networks as Instagram, YouTube and Google Adwords. To develop this study, it has been communicated an agency that gave a budget of 32.000€ during the first year, which will be distributed according to operational needs, investing the 30% of the budget during the launch campaign and the rest for 1 year maintenance.

On the other hand, the website, which will be informative, will be created and managed between the computer technician and the community manager, and the domain costs 14€ per year.

10.1.9 BUDGET SUMMARY

The final budget obtained for the development of the application is described in the next table:

Concept	Monthly Cost	Investment Year 0	1st Year Total Cost
App creation	-	30.250€	
Company creation	-	820€	
Trademark and trade name	-	780€	
Equipment	-	4.900€	
Maintenance	400€		4.800€
Registration Apple/Google	-		124€
Office	1.420€		17.040€ + 2.400€
Personnel Staff	8.500€		102.000€
Comm. and Marketing	-	9.600€	22.400€
	10.320€	**46.350€**	**148.764€**
		195.114€	

Table 10: Budget Summary

According to the total costs obtained of 195.114€, it has been decided to do an estimated investment for AirFree launch of 200.000€.

To get to know how the economy of this business some financial factors were calculated as the payback period, the net present value and finally the internal rate of return. To develop this calculations, it has been supposed a scenario where it is estimated the product's life will be 5 years and an interest rate of 10%.

Year	1	2	3	4	5
Expected Cash Flow	15.000€	90.000€	110.000€	125.000€	135.000€
Accumulated	15.000€	105.000€	215.000€	340.000€	475.000€

Table 11: Expected Cash Flow in 5 years

10.1.9.1. PAYBACK PERIOD

The payback period is the length of time required to recover the cost of an investment. The payback period of a given investment or project is an important determinant of whether to undertake the position or project, as longer payback periods are typically not desirable for investment positions. We calculated as the following knowing that the payback period will start between 2-3 years as the expected cash flow accumulated it becomes bigger than the investment:

$$Payback\ period = 2\ years + \left(\frac{200.000\ € - 105.000€}{110.000€}\right) * 12 months$$
$$= 2\ years\ and\ 10\ months$$

The payback period that the company will need is of 2 years and 10 months approximately, which can be considered good.

10.1.9.2. NET PRESENT VALUE

Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. NPV is used in capital budgeting and investment planning to analyze the profitability of a projected investment or project. The formula used to calculate it is:

$$NPV = \sum_{t=0}^{n} \left(\frac{R_t}{(1+i)^t}\right)$$

Equation 1: Net Present Value

Where:

- R_t = net cash inflow-outflows during a single period t
- i = discount rate or return that could be earned in alternative investments
- t = number of time periods

To calculate the NPV it has been used the excel formula directly with the corresponding data as shown:

Year	0	1	2	3	4	5
Cash Flow	-36.750€	-148.250€	90.000€	110.000€	125.000€	135.000€
NPV	**154.703€**					

Table 12: Net Present Value

Calculations:

Cash Flow Year 1 = Total Investment Year 0 – Total Investment+ Cash Flow Year 1

Cash Flow Year 1 = 36.750€ - 200.000€ +15.000€

With the result obtained we can affirm that it's a successful business because the NPV it's a positive value and it makes profit.

10.1.9.3. INTERNAL RATE OF RETURN

Internal rate of return (IRR) is a metric used in capital budgeting to estimate the profitability of potential investments. Internal rate of return is a discount rate that makes the net present value (NPV) of all cash flows from a particular project equal to zero. IRR calculations rely on the same formula as NPV does. It was also have been calculated by excel:

Year	0	1	2	3	4	5
Cash Flow	-36.750€	-148.250€	90.000€	110.000€	125.000€	135.000€
IRR	**40%**					

Table 13: Internal Rate of Return

We find that the internal rate of return is of 40% which can be considered a high value as we get estimate the profitability of the potential investments during the five years.

11. ENVIRONMENTAL AND SOCIAL ANALYSIS

A study done by the start-up Greenspector, revealed how the use of mobile applications impacts the environment. According to this study, the apps used worldwide by millions of mobile device users consume as much energy as Ireland. To reach this conclusion, the study has evaluated the energy consumption of the top 30 of the most popular mobile applications in the world.

Increasingly demanding in terms of resource techniques as RAM, CPU or data between others… This have an increasing impact on energy consumption and the environment. While data centres are often blamed for greenhouse gas emissions from the digital sector, which will account for almost 10% of global emissions by 2025, mobile apps are not far behind as the study shows.

In relation to social impact, the social impact that the app can cause is the improvement of the lifestyle of some users that will be able to take care more about their health. Furthermore, this app can make them more conscious about air pollution and educate them to care about our environment.

For that reason, in this chapter, an environmental and social analysis has been done by analysing the Life Cycle Assessment (LCA) of the app due evaluating the environmental impact that can be produced and which preventions can be implemented to minimize this impact.

11.1 LIFE CYCLE ASSESSMENT

The life cycle assessment is a design tool that investigates and evaluates the environmental impacts of a product or service during all stages of its existence: extraction, production, distribution, use and end of life (reuse, recycling, recovery and disposal).

In the case of an application, some of those phases are almost avoided, so for AirFree, or any app in general, usually there is no big environmental-social impact as can be for a physical product. So, first it has been identified the different phases of the life cycle of an app:

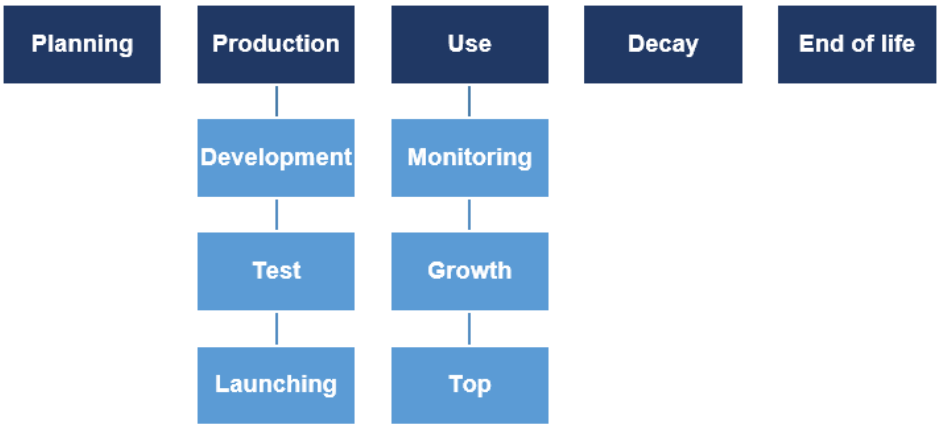


Figure 32: Phases of the Life Cycle of AirFree

- **Planning**

This first stage consists in defining the objectives of the app, and which are going to be the resources needed to be able to create it, as for example, which kind of programming platform will be used.
This phase it's can be considered as the one with less impact, as the resources used can be hours writing down all the ideas and time of research.

- **Production**
  - *Development + Testing + Launching:* in those phases, developers and programmers will develop the code and materialize the idea and make it visual and try it with extern users to be able to improve the application and solve any existent errors.

For this phase consists basically on the development and design of the software by computer, therefore, its greatest environmental impact has been associated with the use of energy resources as electricity used for the operation of the computer equipment.

Electricity consumption has an indirect environmental impact derived from production of that same electricity that is consumed. An average consumption of the computer and the display in on mode is assumed of 0,065 kW [6], and if we consider 4 months of development working 8 hours in weekdays, it's a total of 352 hours. In the next table, Table 14 the electricity consumption is calculated:

Time for development	Consumed Potency	Electricity Consumption
352 h	0,065 kW	22,88 kWh

Table 14: Data on electricity consumption for the development of AirFree

Once, the electricity consumption is calculated, it has been also calculated the atmospheric emissions in Table 15 and the radioactive waste in Table 16 associated with the production of the energy consumed used during the development of the solution. The calculation was made by multiplying the factor obtained from the Observatory of Electricity of Spain [7] by the electricity consumption.

Type of Pollutants	Factor	Electricity Consumption	Atmospheric Emissions
CO_2	0,179 kg/kWh	22,88 kWh	4,10 kg
SO_2	0,417 kg/kWh	22,88 kWh	9,54 kg
NOx	0,283 kg/kWh	22,88 kWh	6,48 kg

Table 15: Pollutant emissions from electricity consumption for the development of AirFree

Type of Radioactive Waste	Factor	Electricity Consumption	Atmospheric Emissions
Low and medium activity	0,00234 cm^3/kWh	22,88 kWh	0,05 cm^3
High activity	0,286 mg/kWh	22,88 kWh	6,54 kg

Table 16: Radioactive waste from electricity consumption for the development of AirFree

- **Use**
  - *Monitoring + Growth + Top:* After the launch of the app, it is important to follow a monitoring process to get to know what is happening with the app and control the phase of growing until arriving to the top of maximum usage based not only on the number of the downloads but also in the behaviour of the users of the app.

    In the monitoring process if the app is well planned, we will return to the development phase to resolve errors, improve it and implement new features. The app improvement phase begins. Otherwise, a new planning stage will be necessary to resolve basic errors that are not related to programming or design.

So, in relation to the environmental impacts it's still the same as the previous phase, the electricity consumption, but in this case cannot be calculated as the monitoring it has to be done always as it is a way of maintenance during all the life of the app.

- **Decay + End-o-f life**

The time it takes for the app to decay will vary depending on the category it is in. Applications in the following categories: Health, Fitness and Medical News, Business and Communication tend to take longer to reach the decline stage. Surely because of the interest they generate in users and the retention capacity, so for that reason we can expect that minimum the 50% of users that downloaded the app will still use during their life as for a lot of them it will be necessary to check the air quality.

To optimize or prevent huge electricity consumption what is proposed it's to extend the phase of planning and the phase of development to be able to create a functional, useful and green app. In this way, the monitoring phase will be with low impact as it will be not such necessary to do drastic changes and work

12. PLANNING FOR FUTURE WORK

The study done until this chapter has been just as first step of a research to be able in the future develop and launch AirFree in the market. In this study it has been only prototyped in an easy way the screens with the multiple features that will be available in Airfree. However, there is a huge and large process to be done until being able to launch the app, so in the next diagram it's shown the future steps to take. In accordance to the diagram, the process to launch the app will take almost 10 months, and the maintenance process will be continuous.

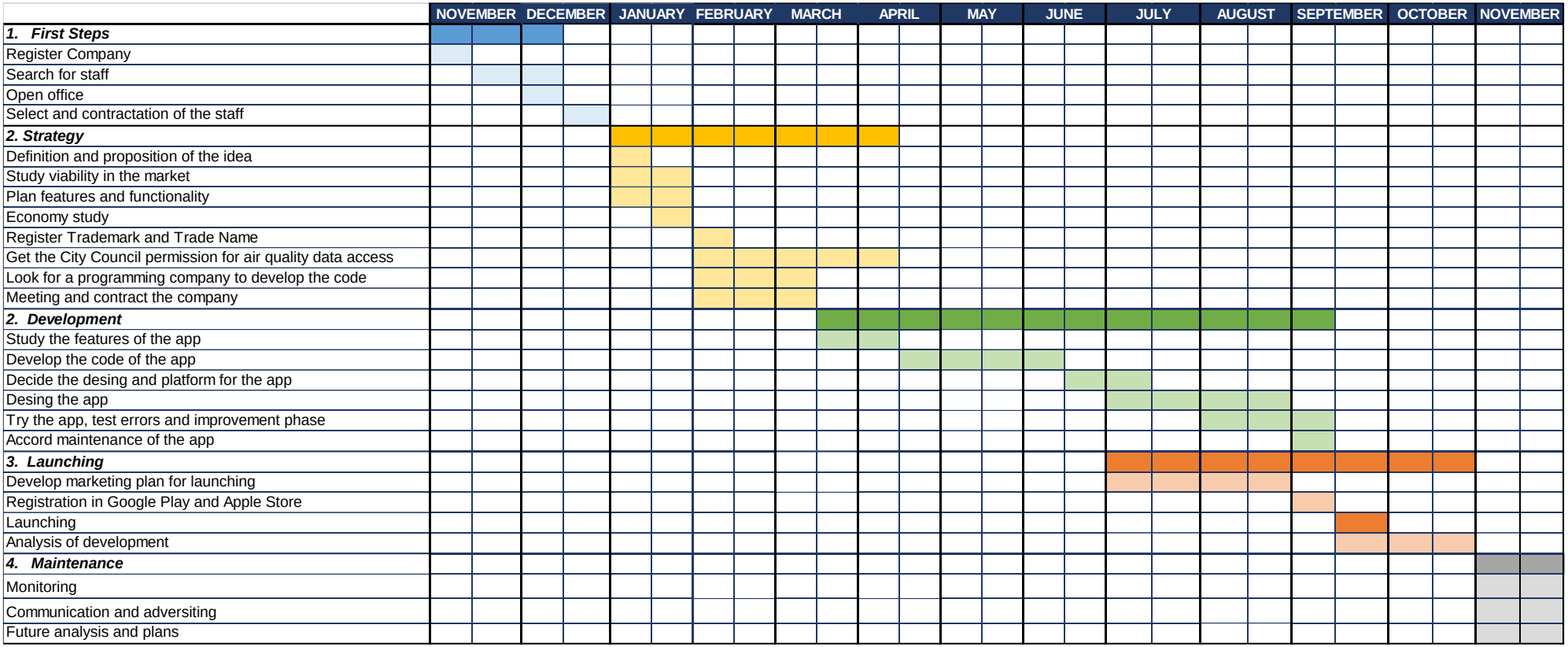


Figure 33: Plan for future work

13. CONCLUSIONS AND RECOMMENDATIONS

At the end of this study, the aim has been accomplished by developing a project management plan for the development of a mobile application for not only sport practitioners, but all the people that their health can be affected by their exposure to air pollution. So, in relation to the scope developed at the begging it can be checked that has been reach completely.

In the first phase, it has been done a schedule of the necessary time to realize the project, which consisted in almost 770 hours that is detailed in the WBS, but instead it has taken approximately 944 hours. The main reason for this, it was due the needed time for collecting data from interviews, that took the double time as expected. Furthermore, in the WBS it was not considered the enough time to develop the economic analysis as it has taken even the triple time due the timing needed of contacting with different programming companies, publicity companies and even governmental institutions to know the exact price taxes.

After, it was necessary to reaffirm the importance of air quality in our health. So, for that reason it has been done a bibliographical research to get to know more about the topic and be able to justify it.

In order to proceed to the development of the features of the app, before, it has been studied the similar apps available in the market and which features they have to be able to create a unique app with new features.

Next, it has been used the design thinking process to understand the user's needs to develop the current features to fulfil their needs. This process has been totally a successful process as it has given the opportunity to know from the first hand the needs of sport practitioners in relation to this app and arrive to the conclusion that all of them are agree that the app should be directed to more people. For that reason, it has been developed a prototyped app which has a lot of variety in features according to the belonging group, as people with respiratory illness, pregnant women, children, elderly or just sport practitioners. The strong feature in AirFree that is not available in any other similar app, is the possibility to check their contamination exposure during all the day in a very personalized way.

In relation to the viability study, it has been demonstrated how this app sector is constantly increasing and that has made us to positionate AirFree in the highest ranges due its differentiation from the rest similar apps.

The estimated budget to be able to develop AirFree and create a brand with a continuous company following up the development in the market is of 195.114€. This costs compared with

similar applications its quite good, however, it's still being a huge number after seeing that the payback period its almost of 3 years, exactly 2 years and 3 months, whereas other applications start creating profit from the first year. Anyways, a commercialization scenario was proposed to calculate the net present value and the internal rate of return that demonstrated that the app will be rentable and profitable quite much.

For the environmental evaluation, it has been seen that an application does not have big impacts really unless of electricity. The consumption of electricity calculated for developing the code and designing is of 22,88 kWh. Furthermore, the emissions of different pollutants have been calculated as seen in Table 16, and comparing this results with the emissions of a physical product it has nothing to do, so we can conclude that the development of an app does not have a big environmental impact.

In terms of social impact, it has been realised that AirFree will not only be useful for the users to check any information they want, it is also a way to make the society more conscious about air pollution and how to care more about our planet to have fresh air to breath and stay safe.

Finally, it has been developed a plan for future work to follow to be able to launch the app in the market and continue with constant improvement. It has been concluded that it can take almost 10 months to be able to launched, because is not only about the 4 months of external development, but also it takes a lot of time to get some permissions from national institutions as the access to air quality data from the City Council.

14. REFERENCES

[1] World Health Organization, 2019. *How air pollution is destroying our health*

https://www.who.int/airpollution/news-and-events/how-air-pollution-is-destroying-our-health

[2] European Environment Agency, 2020. *Health impacts of air pollution.*

https://www.eea.europa.eu/themes/air/health-impacts-of-air-pollution

[3] Tze-Ming, Ware G., Kuschner MD., Scott P. *Outdoor Air Pollution: Nitrogen Dioxide, Sulfur Dioxide, and Carbon Monoxide Health Effects.* The American Journal of the Medical Sciences. 2007; 249-256

[4] J. Zhang, I. Adcock, Z. Bai. *Health effects of air pollution: what we need to know and to do in the next decade.* Journal of Thoracic Disease. 2019; 1-4

[5] ResearchGate, 2012. *Effect of air pollution in athlete health and performance.*

https://www.researchgate.net/publication/221768608_Effect_of_air_pollutionon_athlete_health_and_performance

[6] LeanTricity, 2012. *Cuanta energía gasta un ordenador*

http://www.leantricity.es/es/2012/07/11/cuanta-energia-gasta-un-ordenador aproximaciones/

[7] WWDF, 2014. *Observatorio de la Electricidad*

http://awsassets.wwf.es/downloads/oe_mayo_02062014

[8] The Guardian, 2019. *Impact of air pollution on health may be far worse than thought, study suggest*

https://www.theguardian.com/environment/2019/nov/27/impact-of-air-pollution-on-health-may-be-far-worse-than-thought-study-suggests

[9] World Health Organization, 2019. *Ambient air pollution: Health impact*

https://www.who.int/airpollution/news-and-events/how-air-pollution-is-destroying-our-health

[10] Di Q, Dai L, Wang Y, et al. *Association of Short-term Exposure to Air Pollution With Mortality in Older Adults.* JAMA. 2017; 52-57

[11] Di Q, Wang Y, Zanobetti A. *Air Pollution and Mortality in the Medicare Population*. 2017; 18-22

[12] Xiang J, Weschler CJ, Wang Q. *Reducing Indoor Levels of "Outdoor $PM_{2.5}$" in Urban China: Impact on Mortalities.* Environ. 2019; 20-27

[13] Silva RA, West JJ, Lamarque JF. *Future Global Mortality from Changes in Air Pollution Attributable to Climate Change.* Natural. 2017; 51-59

[14] Robert D., Sanjay R., Aruni B., Fernando H., David S. *Particulate Matter Air Pollution and Cardiovascular Disease.* Journal of the American Heart Association. 2010; 4-12

[15] MakeUseOf, 2020. *The 7 Best Apps and Sites to Check Air Quality Anywhere.* https://www.makeuseof.com/tag/check-air-quality-apps/

[16] Bustle, 2019. *7 Air Quality Apps to Download To Help Plan Your Days During Allergy Season.* https://www.bustle.com/p/7-air-quality-apps-to-download-to-help-plan-your-days-during-allergy-season-17135236

[17] Interaction Design Foundation, 2020. *Design Thinking: A 5 Stage Process* https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process

[18] ResearchGate, 2019. *Viability Study of Product*

https://www.researchgate.net/figure/Viability-study-defined-structure_fig4_245291524

[19] ScienceDirect, 2019. *Life Cycle Assessment*

https://www.sciencedirect.com/topics/earth-and-planetary-sciences/life-cycle-assessment